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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 820

Contribution from the Forest Service
HENRY S. GRAVES, Forester

Washington, D. C. ▼ May 22, 1920

JACK PINE

By

WILLIAM DENT STERRETT, Forest Examiner

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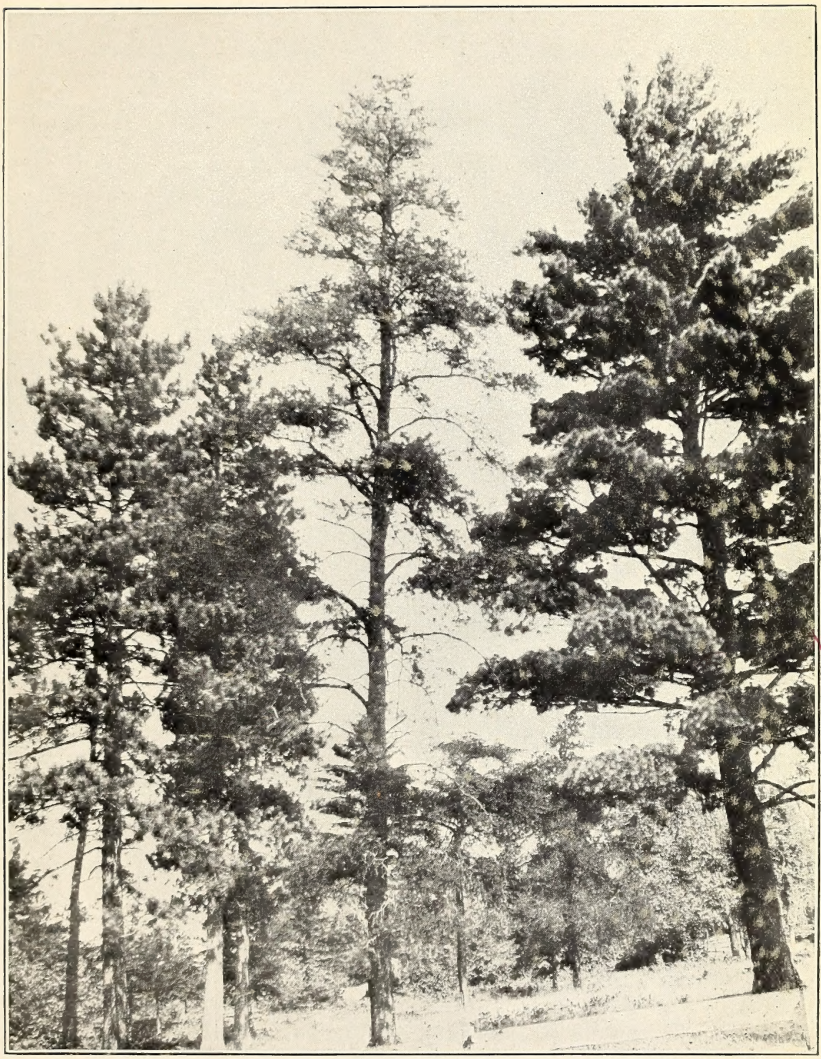

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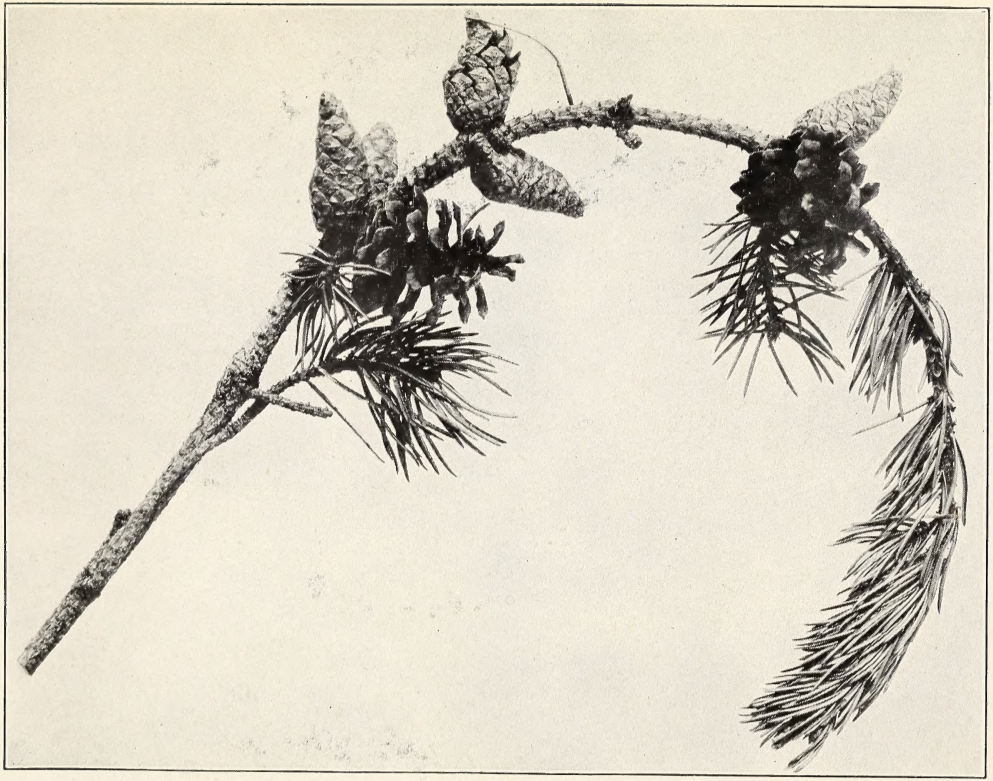
CHARACTERISTIC APPEARANCE OF DENSE-FOLIAGED WHITE PINE ON THE RIGHT, THIN-FOLIAGED JACK PINE IN THE CENTER, AND MEDIUM-FOLIAGED NORWAY PINE ON THE LEFT.



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OPENED JACK PINE CONES, WHICH SHED THEIR SEED SEVERAL YEARS AGO, AND, ON THE SAME BRANCH, UNOPENED CONES CONTAINING FERTILE SEED.

In case of lumbering and fire the latter also open up and shed their seed.

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JACK PINE.

By WILLIAM DENT STERRETT, *Forest Examiner.*

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INTRODUCTION.

Jack pine[1] is a very frugal tree in its climatic and soil requirements. The northern limit of its natural range is within 1½ degrees of the Arctic Circle and the southern is marked by the southern shores of Lake Michigan. No other North American pine grows naturally so far north and all the others grow farther south. It develops commercial stands and reproduces itself on dry, barren, sandy ridges and plains unsuited to other native trees. The seed germinates more quickly and grows more rapidly in its early years on lumbered and burned-over forest land and on idle, worn-out, cleared land than the other pines occurring within its range. On good soils or on poor soils with a cover of moisture-conserving mulch resulting from forest growth it gives way to longer lived species. The fires which are common on jack pine lands burn off the litter, keep the soil impoverished,

[1] Jack pine was described under the name of *Pinus divaricata* by Du Mont de Courset in 1802, and a year later by Lambert as *Pinus banksiana* (named after Sir Joseph Banks). From the latter are derived the names Banksian and Banks pine, by which names the tree is commonly known in Europe and in European forestry literature. Lambert's description of it was from a tree planted in England some time in the eighteenth century. The latter name is more widely used than the former, especially in Europe, but by the law of priority in nomenclature *P. divaricata* is the correct name. The term *divaricata*, meaning spreading apart or forked, is especially appropriate for jack pine trees growing in the open. The following common names are applied to the tree in different parts of the country: Scrub pine, general; gray pine, Vermont, Minnesota, and Ontario; jack pine, Lake States and Canada; Princess pine, New Brunswick and Nova Scotia; black jack pine, Wisconsin; black pine, Minnesota; cypress, Quebec to Hudson Bay; Canada horncone pine; check pine (probably a corruption of jack pine); Sir Joseph Banks pine, England; juniper, Canada; Banksian pine, European literature; Labrador pine; and Hudson Bay pine.

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and prolong the tenure of jack pine over extensive areas of sandy ridges and plains. There are large areas with poor soil and severe climate, especially in Canada, on which jack pine is the permanent forest growth. It is, therefore, one of the characteristic forest types of the North.[1]

In the Lake States jack pine produces chiefly small-sized, knotty lumber, much inferior to that from the Norway and white pines which grow with it. It has, however, good possibilities of profitable utilization for pulpwood, box boards, mine timbers, and other low-grade material. Its rapid growth when young, its good yields per acre on poor land, and the ease which it reproduces itself make it suitable for timber growing on a short rotation.

Jack pine is an important tree for forest management on poor, sandy soils in the region of its natural distribution, and has been successfully planted outside of its natural range in the sand hills of western Nebraska. In the Lake States there are hundreds of thousands of acres of poor, sandy plains-land, impoverished by fires, on which jack pine is a pioneer tree, forming stands by natural reproduction where white and Norway pine have not appeared. These two species come in later with improved soil conditions and under the shelter of the jack pine. Wherever good stands of jack pine can be secured without expense by natural reproduction, that is usually preferable to planting the land with more valuable species at considerable expense and with less certainty of success.

DISTINGUISHING CHARACTERISTICS.

Jack pine has leaves in bundles of two, from $\frac{3}{4}$ to $1\frac{3}{4}$ inches long, flat, or slightly concave on their inner surface, and surrounded by a short sheath. The cones are from $1\frac{1}{2}$ to 2 inches long, oblique at the base, sessile, erect, and strongly incurved, with thick, soft scales, armed with minute, incurved prickles which usually fall away. (See Pls. I and II.)

The only other two-leaved pine with which jack pine is likely to be confused is the lodgepole (*Pinus contorta*). The ranges of these two species overlap slightly in central western Alberta.[2] Their leaves are about the same size, and their cones are very similar. The cones of both are curved, but those of jack pine are erect or pointing in the direction of the end of the twig, while those of lodgepole are horizontal or declining, pointing upward or even backward. Jack pine is further dis-

[1] The growth, yield, form, and volume tables which are the chief basis for this bulletin were compiled mostly from measurements taken in 1905 on pure, dense, even-aged stands of jack pine in Hubbard County, Minn., by Prof. H. H. Chapman, of the Yale Forest School. The bibliography of data used and reports consulted in the preparation of this bulletin is found on page 34 (appendix).

[2] "The lodgepole is ordinarily confined to higher elevations in Alberta. The upper portions of river slopes will be occupied by lodgepole pine, while the lower slopes and bottom lands may be covered with pure jack pine. As the river is followed into the hills the lodgepole pine gradually replaces the jack pine on the lower levels and finally occupies the whole river bottom and side slopes."—Extract from a letter by R. H. Campbell, Director of the Canadian Forestry Branch.

tinguished by absence of permanent prickles on the cones. Most characteristic, however, is the position of the cones. In jack pine the cones are subterminal; that is, they grow near the ends of the twigs. In lodgepole pine the cones are lateral; that is, they grow on the sides of the larger twigs.

RANGE.

Jack pine ranges from the southern shores of Lake Michigan to latitude 65° on the Mackenzie River, and from Nova Scotia to the southeastern corner of Yukon Territory and northeastern British Columbia, extending nearly to the foothills of the Canadian Rockies. (See fig. 1).[1] Its range east and west is some 2,500 miles; its north and south extension is 1,600 miles, and averages about 600 miles along any meridan.

In the United States jack pine ranges from western Maine through northern New Hampshire and northern New York, and extends north from northwestern Indiana, northeastern Illinois, through most of Michigan, Wisconsin, and Minnesota. It has also been extensively and successfully planted in the sand hills of western Nebraska. Its occurrence in commercial stands in the United States is limited to certain parts of the Lake States—the Northern Peninsula and the northern half of the Southern Peninsula of Michigan, the northern half of Wisconsin, and the northern half of Minnesota east of the ninty-sixth meridian. In the eastern States it is always a small tree occurring in small, widely scattered groups on sandy barrens.

In Canada jack pine has a much greater range and is of more importance commercially than in the United States. It occurs most abundantly in northern Ontario and Quebec, and in Manitoba, Saskatchewan, and Alberta. In the region west of Lake Winnipeg it reaches a fine development. It is found north of the Saskatchewan River as far west as Fort Assiniboine, and extends north into the valley of the Mackenzie River. It is one of the most abundant trees in the extensive but largely noncommercial forests which cover northern Canada.

GEOLOGY AND CLIMATE OF THE JACK PINE REGION.

The soil in which jack pine occurs in southern Canada, New England, New York, and the Lake States is largely of glacial origin, deposited and spread out by the waters of the melting ice sheet in the last glacial period. To the north, including portions of northern Minnesota and throughout most of its range in Canada, the country is for the most part a region of crystalline rock (granite, gneisses, and schists) severely glaciated and denuded of its mantle of original alluvial soils and only partially covered with thin, light soils of recent

[1] Botanical range outlined by W. H. Lamb, of the Section of Forest Distribution; commercial range in Canada furnished by R. H. Campbell, Director of the Canadian Forestry Branch; and for the United States by the author.

origin developed by the weathering of the underlying rock. This is the "Great Laurentian Shield," which comprises over 50 per cent of the area of Canada and extends from the northwest arm of the Lake of the Woods, northwestward and northward to the mouth of the Mac-

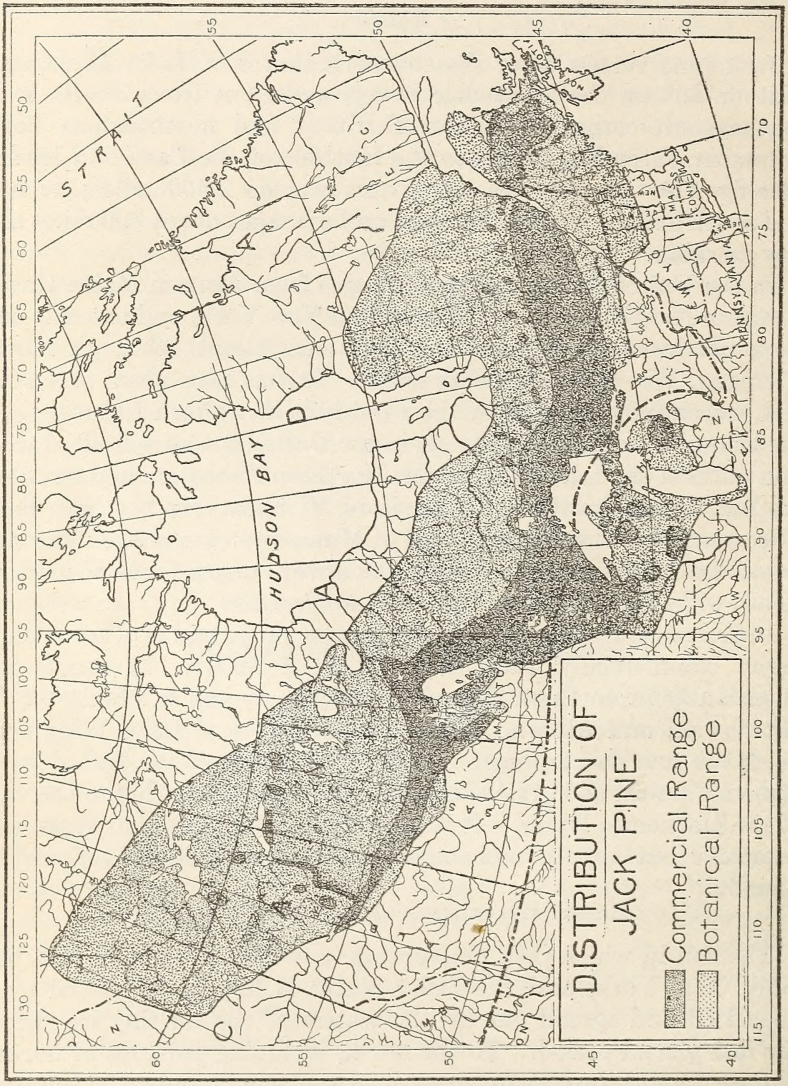

FIGURE 1.

kenzie River, the Arctic Ocean, and the mouth of the Winnipeg River, and eastward through Ontario, Quebec, and Labrador. (See fig. 1.) Lakes, rivers, and swamps alternate with low hills and plateaus, which show a remarkably even sky line. The network of waterways extends throughout the region. The soil is found mostly along stream valleys (alluvial), on the southern exposures of ridges (glacial sands

F–61393

FIG. 1.—TYPICAL OCCURRENCE OF JACK PINE IN MIXTURE WITH NORWAY AND WHITE PINE AND SCRUBBY SCARLET OAK ON EDGE OF PLAINS TYPE.

F–60914

FIG. 2.—YOUNG STAND OF JACK PINE AND THE OLD SEED TREES WHICH PRODUCED IT.

F-32820A

FIG. 1.—JACK PINE, 35 YEARS OLD, OVERTOPPING BUR OAK, 100 YEARS OLD, ON SANDY, JACK PINE SOIL, ADAMS COUNTY, WIS.

This is a common occurrence.

F-32812A

FIG. 2.—JACK PINE, 40 YEARS OLD AND 56 FEET HIGH, SLIGHTLY OVERTOPPING POPPLE, OF SAME AGE AND 48 FEET HIGH, ON SANDY, JACK PINE SOIL IN ADAMS COUNTY, WIS.

The popple was more severely damaged by fire 12 years ago than was the jack pine.

JACK PINE IN COMPETITION WITH HARDWOODS ON TYPICAL SANDY JACK PINE LAND IN ADAMS COUNTY, WIS.

and gravels), and collected in pockets. There are immense areas barren or valuable only for timber growing.

Jack pine is distinctly a tree of cold climates. Great variations of temperature take place within its range, and it occurs, for instance, where the winter temperature is often 60° F. below zero and the summer heat sometimes over 105° F. above. The growing season within its range varies from two to four months.

The heaviest rainfall of the jack-pine belt is in parts of Nova Scotia and New Brunswick, where it usually amounts to from 20 to 40 inches annually. The precipitation in the western portions of its range varies from 14 to 29 inches a year. Although essentially a dry-land tree, jack pine demands a climate with a moderate rainfall and produces the best stands where the annual precipitation is about 25 inches. Snowfall is generally abundant throughout its region of distribution, and protection is thereby afforded to the ground and the young growth.

FOREST TYPES.

Jack pine occurs chiefly in the following forest types: (1) In pure stands, on what is known as jack-pine land; (2) in mixture with Norway pine, on Norway pine land; (3) in mixture with white pine and other species, on white pine land; (4) in mixture with poplar (aspen); (5) in coniferous swamps and muskegs. The first and the last of these forest types occur throughout the range of the species, while the second and third are limited to the United States and the southern part of Canada. In general, the types in which jack pine occurs are relatively transient ones, as this species perpetuates itself in nature largely through the accidental agency of fire. (See Pls. III, IV, and V.)

JACK PINE LAND.

Land composed of poor, medium-to-coarse sands or land which is impoverished by fire and on which Norway or white pine does not readily spring up and thrive is the kind on which pure or nearly pure stands of jack pine constitute one of the principal forest types of the North. Even on this land, if for a number of years fires are excluded, soil and humus conditions improve and jack pine gradually gives way to the longer-lived and more persistent Norway pine, or in some cases to spruce. In the Lake States this land is usually known as "jack pine plain" because of its comparatively flat topography. In Canada it is usually known as "jack-pine ridge," although often it is only a few feet in elevation above the level of the coniferous swamp or muskeg. In the Lake States the "jack pine plain" in many cases formerly supported a good growth of Norway or white pine and the process of reversion to these species is now going on. On the border of the prairie region in Minnesota and Manitoba, "jack-pine prairies" occur which have only a scattering growth of small jack pine trees.

NORWAY PINE LAND.

Jack pine is found in mixture with Norway pine on fresh-to-dry flats and ridges of fine sand, jack pine sometimes composing one-half the stand.

WHITE PINE LAND.

On moist flats of very fine sand and silt, where white pine thrives, jack pine occurs sporadically as a subordinate tree. After lumbering and burning on these lands, however, jack pine may take possession and for a while form the dominant growth.

JACK PINE AND POPLAR (ASPEN).

Considerable areas bearing jack pine and poplar (aspen) are found in the western part of the range of jack pine in Canada. The type varies "from jack pine scattered in poplar to poplar scattered in jack pine. In these areas the jack pine is usually of very good growth, since it occupies better soils than it usually does."[1]

CONIFEROUS SWAMPS AND MUSKEGS.

In the Lake States jack pine grows only occasionally in swamps, but toward the north, as the number of tree species inhabiting muskegs gradually decreases, the proportion of jack pine in them becomes larger. However, in this type the jack pine is seldom of commercial importance.

Tables 29, 30, and 31 (appendix) show what species occur, more or less abundantly, with jack pine in the Lake States and in Canada on land where it is the prevailing tree. The appearance of tamarack and ash in Table 29 indicates that the edge of a swamp was included in some of the acres measured, as these species are not found in any of the jack-pine forest types.

SOIL, MOISTURE, AND LIGHT REQUIREMENTS.

Jack pine is primarily a tree of light, dry, medium to coarse, thoroughly drained sands and gravels. It is confined to geological formations which contain no limestone.[2] One of its important characteristics is its ability to reproduce and grow fairly well on thin, dry, sandy uplands where other species will not grow. Jack pine grows best, however, on fairly deep upland flats, where the drainage is good but the water table fairly near the surface. This is really Norway pine land, from which Norway pine usually crowds out the jack pine if fires are kept out.[3] (See Pls. V, VI, and VII.)

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[1] Extract from a letter by R. H. Campbell, Director of the Canadian Forestry Branch.

[2] See B. Moore in Vol. XVII, p. 887, of the Journal of Forestry.

[3] Table 17 (appendix) indicates that in northern Minnesota jack pine stands occur prevailingly on medium to coarse sands, Norway pine stands on fine sand, and white pine stands on very fine sands and silts. (Medium to coarse sands comprise in a large degree the "Soils of the Laurentian country in Canada, where jack pine reaches its best development." See Forestry Quarterly, Vol. IX, No. 1, p, 7.)

Most of the soil on which jack pine occurs has little or no accumulation of humus. Accumulation of humus would mean, in some cases, improved soil conditions and the ousting of jack pine by more persistent, longer-lived species.

Jack pine requires at least 10 per cent of water in the soil for its best growth. On very dry soils young stands of jack pine may do well at the outset, but the growth is not sustained, the trees do not reach large size, and the stand becomes more open because of competition for soil moisture. To a limited extent jack pine grows in swamps also, but in a stunted form.

Jack pine is intolerant of shade, somewhat more so than Norway, and considerably more so than white pine. For this reason it is unable to reproduce itself under the shade of mature trees. Jack pine stands which are dense up to the age of from 30 to 50 years thin out rapidly thereafter even on good sites. On lands suited to white or Norway pine, but which become seeded up to dense stands of jack pine following lumbering and fire, these species, through their superior tolerance and persistence in growth, gradually seed in and push themselves up through the jack pine and kill it out entirely, not, however, before the jack pine has reached merchantable size.

FORM AND DEVELOPMENT.

In dense stands jack pine is a tall, slender tree, with a short crown and a long bole. In open stands it tends to develop a dome-shaped, wide-spreading crown and a short bole. The dead branches are very persistent, normally remaining on the trunk from the live crown almost to the ground during most of the life of the tree.

The size of a mature jack pine tree varies greatly in different portions of its range. In northern and western Minnesota, where jack pine forests attain their best development in the United States, dominant forest-grown trees which reach maturity when from 80 to 100 years old are usually from 60 to 80 feet tall and from 10 to 15 inches in diameter at breast height. Older trees are frequently found which are 85 feet high and 15 or 16 inches in diameter. Trees 90 feet in height and over 20 inches in diameter are sometimes found, but these are the exception, and indicate better soil conditions than usually obtain where jack pine grows. After reaching 80 years of age, and sometimes sooner, jack pine deteriorates rapidly.

On the jack pine plains in the northern half of the Southern Peninsula of Michigan there are many miles of pure young jack pine forest in which there are few, if any, trees over 75 feet in height or more than 14 inches in diameter. Frequent fires have thinned many of these stands and as a result large numbers of the trees are scrubby and branchy. On the Michigan National Forest in the Lower Peninsula jack pine averages from 4 to 6 inches in diameter and from 30 to 40

feet in height, and only infrequently is it found over 8 or 9 inches in diameter and 50 feet in height. The small diameter of the trees is explained by the fact that most of the stands are comparatively young. In the Upper Peninsula of Michigan jack pine stands occur on better soils and are favored with a heavier rainfall than are those found in the lower peninsula. Therefore the average size of the trees is larger and the quality is better. Trees have been found here 18 inches and over in diameter, 90 feet in height, and 150 years of age. (See Pl. VIII.) Most of the stands are, however, composed of young and small trees.

On the eastern outskirts of its range in New England where a few jack pine groves occur, the height of the trees is usually only from 15 to 20 feet. These groves are composed of comparatively young trees. In Nova Scotia and eastern Canada also this species is of small size.

In the region north and west of Lake Superior and west of Lake Winnipeg jack pine reaches its best development. Here it is occasionally 90 feet in height and 20 inches in diameter. North of Lake Winnipeg it seldom exceeds 8 inches in diameter and 50 feet in height.[1]

Tables 18 to 28 (appendix) indicate the form and growth of jack pine trees in regard to width of crown, thickness of bark, taper, and volume expressed in different units of measure.

ROOT SYSTEM.

On deep, sandy soil where the water table is low, jack pine produces a long characteristic taproot. On loose soil the lateral roots spread outward only a short distance and then descend parallel to the taproot. During the first year seedlings on this quality of soil send a taproot down from 6 to 12 inches, and develop very few laterals. (See fig. 2.) On better soils a widely branched, surface-feeding root system is developed early because of the relatively large amount of food and moisture near the surface. At the same time a more or less pronounced taproot is sent down, though this does not develop as rapidly as on sandy soil. On shallow and wet soils jack pine develops only lateral roots.

RATE OF GROWTH.

Tables 1 to 8, inclusive, indicate the rate of increase in diameter and height of single trees of jack pine growing in different regions and under different conditions.

[1] See Forestry Quarterly, December, 1916.

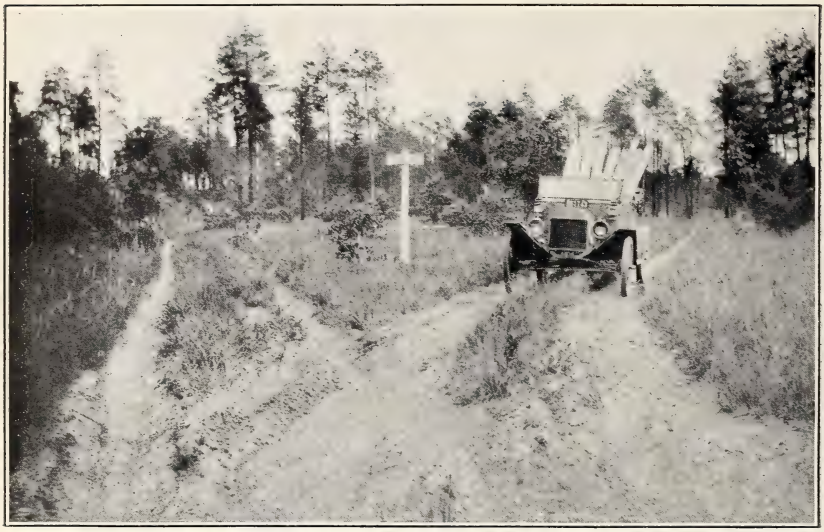
F–34551A

FIG. 1.—NORWAY PINE REPRODUCTION COMING IN UNDER A THICK STAND OF JACK PINE IN WHICH THERE HAS BEEN NO FIRE FOR A NUMBER OF YEARS.

F–25566A

FIG. 2.—STAND OF JACK PINE 150 YEARS OLD ON SANDY RIDGE BETWEEN SPRUCE-TAMARACK SWAMPS.

There has been no fire here for some time and a spruce understory has sprung up in places.



F-34752A

FIG. 1.—TYPICAL JACK PINE PLAIN OF VERY SANDY SOIL.

F-75101

FIG. 2.—TYPICAL GROWTH OF JACK PINE ON JACK PINE PLAINS IN MICHIGAN. STAND DENSE IN SPOTS AND OPEN IN OTHERS.

F–64793

FIG. 1.—FORTY-FIVE-YEAR-OLD STAND ON CLAY SOIL, SHOWING UNDERBRUSH WHICH IS TYPICAL OF GOOD SOILS WHERE THERE HAS BEEN NO FIRE.

F–64786

FIG. 2.—FIFTY-FIVE-YEAR-OLD STAND ON PURE SAND, SHOWING WELL-CLEANED BOLES.

Note lack of undergrowth on sandy site. Also trees thinning out and growth at a standstill.

DENSE STANDS OF JACK PINE ON CLAYEY AND SANDY SOILS. HUBBARD COUNTY, MINN.

F—25567A

STAND 150 YEARS OLD AND TREES 10 TO 18 INCHES IN DIAMETER, 70 TO 90 FEET HIGH, AND 30 TO 50 FEET CLEAR LENGTH, ON LOW SANDY RIDGE BETWEEN SPRUCE-TAMARACK SWAMPS.

A very exceptional stand of jack pine in regard to size and age and quality of the timber. Overmaturity is indicated by the unhealthy appearance of the crowns.

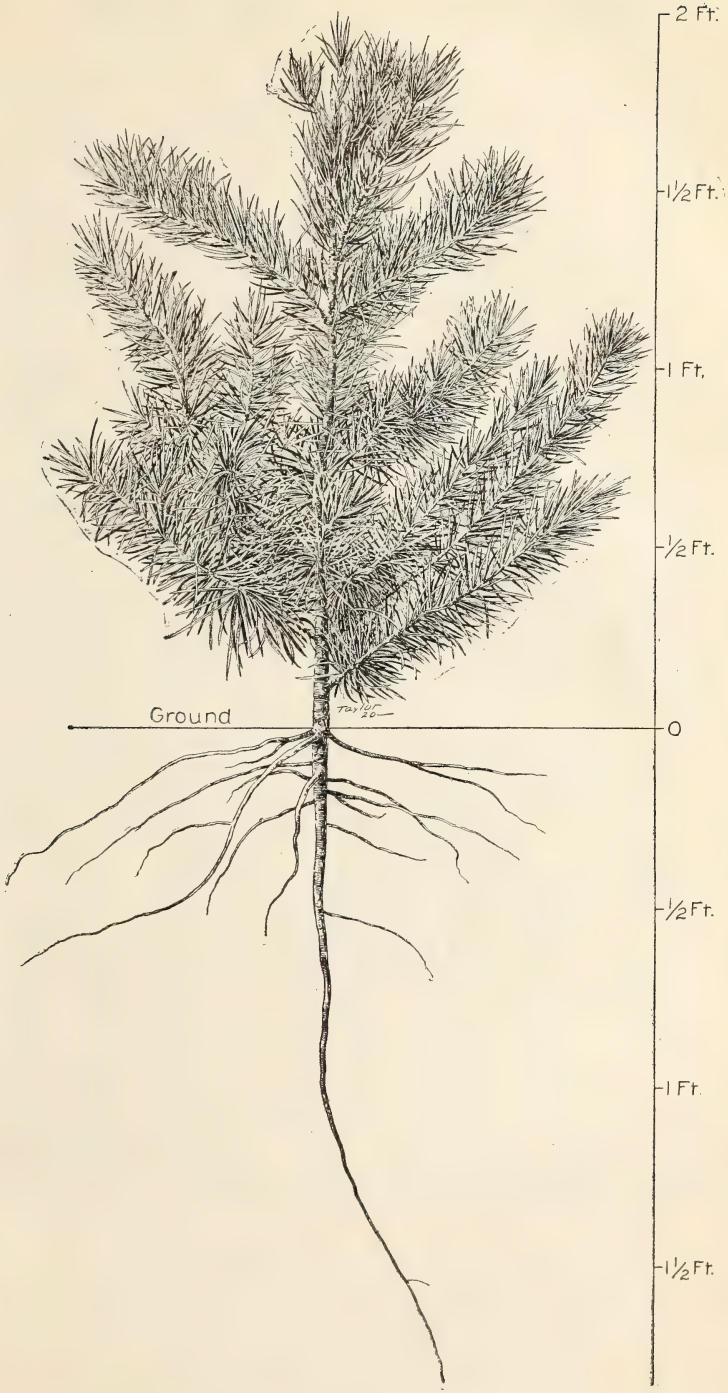


FIG. 2.—Three-year-old jack pine 2 feet high showing well-developed root system with long tap root.

TABLE 1.—*Rate of growth in diameter and height of jack pine, in dense stands and of isolated or nearly isolated trees, in Hubbard County, Minn.*

Age.	Trees in dense stands 18 to 99 years old.				Isolated or nearly isolated trees 22 to 82 years old.	
	Average.		Maximum.		Average growth.	
	D. b. h.	Height.	D. b. h.	Height.	D. b. h.	Height.
Years.	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*
10	1.2	9	1.8	19	1.7	12
15	2.3	16	3.8	26	3.5	22
20	3.3	22	5.5	33	5.1	29
25	4.0	28	6.9	38	6.6	35
30	4.6	33	7.9	42	7.9	39
35	5.1	38	8.8	46	9.1	42
40	5.6	42	9.5	50	10.2	44
45	6.1	45	10.2	53	11.1	46
50	6.5	48	10.9	56	11.8	47
55	6.9	51	11.5	59	12.5	47
60	7.3	54	12.1	62	13.1	48
65	7.6	57	12.7	65	13.7	49
70	8.0	59	13.3	68	14.2	49
75	8.3	62	13.9	70	14.8	50
80	8.7	64	14.5	72	15.3	50

Based on 604 trees, 18 to 99 years old. Measurements by H. H. Chapman.

Table 1 indicates a much faster diameter growth of isolated and partly isolated trees than the average growth of trees in dense stands—faster even than the average growth of predominant trees in such stands.

TABLE 2.—*Rate of growth in diameter and height of jack pine in Cass County, Minn.*

Age.	Average.		Maximum.		Age.	Average.		Maximum.	
	Diameter breast high.	Height.	Diameter breast high.	Height.		Diameter breast high.	Height.	Diameter breast high.	Height.
Years.	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Years.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*
5	.....	3	.....	12	65	8.4	63	11.1	72
10	0.6	10	1.4	20	70	8.8	65	11.6	74
15	1.5	16	2.8	28	75	9.2	68	12.1	76
20	2.4	23	4.1	35	80	9.6	70	12.6	78
25	3.3	30	5.3	41	85	10.0	71	13.0	80
30	4.2	35	6.3	47	90	10.4	73	13.4	82
35	5.0	40	7.2	52	95	10.8	74	13.8	83
40	5.7	45	8.1	57	100	11.2	75	14.2	85
45	6.3	50	8.8	61	105	11.6	76	14.6	86
50	6.9	53	9.5	64	110	11.9	77	15.1	88
55	7.4	57	10.1	67	115	12.3	78	15.5	89
60	7.9	60	10.6	70	120	12.6	79	15.9	90

Based on 52 trees 69 to 124, averaging 93 years old, and 7 to 16 inches in diameter, the trees having been cut for saw logs. Measurements by J. St. J. Benedict.

TABLE 3.—*Rate of growth in diameter of second-growth jack pine in northern Minnesota.*

Age.	Diameter breast high.		Age.	Diameter breast high.	
	Maximum.	Average.		Maximum.	Average.
Years.	*Inches.*	*Inches.*	*Years.*	*Inches.*	*Inches.*
5			30	7.7	5.7
10	1.8	1.2	35	8.6	6.5
15	3.6	2.5	40	9.5	7.3
20	5.2	3.8	45	10.3	8.1
25	6.5	4.8	50	11.1	8.9

NOTE.—Based on decade measurements on 46 1-foot stumps 32 to 51 years old. Measurements by J. St. J. Benedict, in Cass County, Minn.

TABLE 4.—*Rate of growth in diameter and height of dominant jack pine trees in Crawford and Roscommon Counties, Mich.*

Age.	Average dominant growth.		Maximum growth.		Age.	Average dominant growth.		Maximum growth.	
	Diameter breast high.	Total height.	Diameter breast high.	Total height.		Diameter breast high.	Total height.	Diameter breast high.	Total height.
Years.	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Years.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*
5		2		4	55	8.4	55	11.0	67
10	0.8	8	1.5	13	60	8.8	58	11.5	70
15	2.0	15	3.2	22	65	9.2	61	12.0	72
20	3.1	22	4.8	31	70	9.6	63	12.4	74
25	4.2	28	6.3	39	75	10.0	64	12.8	75
30	5.2	34	7.5	45	80	10.3	65	13.1	76
35	6.0	39	8.4	51	85	10.7	66	13.5	77
40	6.7	44	9.3	56	90	11.1	67	13.9	78
45	7.3	48	9.9	61	95	11.5	67	14.3	79
50	7.9	52	10.5	64	100	11 8	68	14.7	80

Diameters based on decade measurements on 122 1-foot stumps 25 to 104 years old. It was assumed that it would take 4 years to grow to a stump height of 1 foot.
Heights based on sectional age counts on 150 trees 25 to 104 years old.
Measurements by T. H. Sherrard, 1901.

TABLE 5.—*Measurements*[1] *on 13 trees in a dense young stand of jack pine on sandy pine plain in the Upper Peninsula of Michigan.*

[The trees were cut for pulpwood in 4-foot lengths and taken to a top diameter of 4 inches, with an average of 122 pieces per cord. See Pl. XII.]

	Average.	Maximum.	Minimum.
Age.....years..	47	55	40
Height.....feet..	50.8	57	44
Diameter, breast high.....inches..	6.9	9	5.5
Volume in board feet (possible mill cut of round-edge material).....	28	60	15
Clear length.....feet..	0	0	0
Merchantable length.....feet..	31.6	44	24
Number of 4-foot sticks per tree.....	8	11	6

[1] Measurements by Huber C. Hilton, 1918.

TABLE 6.—*Measurements*[1] *on 22 trees in a fairly dense, somewhat mature to overmature stand of jack pine in the Upper Peninsula of Michigan.*

[The trees were cut for saw logs. Stand located on a low sandy ridge, slightly elevated above a muskeg swamp on one side, and above a lower area of spruce, tamarack, and some jack pine on the other. Soil, coarse sand underlaid with clay subsoil. See Pl. VIII.]

	Average.	Maximum.	Minimum.
Age.....years..	104	125	68
Height.....feet..	72.5	88	61
Diameter, breast high.....inches..	12.2	17	9.8
Volume in board feet, Scribner decimal rule.....	128	290	50
Volume in board feet (mill scale of possible round-edge).....	175	430	90
Clear length.....feet..	34	50	0
Merchantable length.....do....	46.4	60	32
Number of 16-foot logs.....	3	3¾	2

[1] Measurements by Huber C. Hilton, 1918.

TABLE 7.—*Rate of growth, in diameter and height, of jack pine, on good sites in western Ontario.*[1]

Age	Diameter breast high.	Height.	Age.	Diameter breast high.	Height.
Years.	*Inches.*	*Feet.*	*Years.*	*Inches.*	*Feet.*
5.....	....	1.5	60.....	11.7	64
10.....	0.8	8	65.....	12.4	67
15.....	2.0	17	70.....	13.0	70
20.....	4.0	28	75.....	13.5	72
25.....	5.8	36	80.....	14.0	74
30.....	7.1	42	85.....	14.5	76
35.....	8.1	46	90.....	14.9	77
40.....	8.9	50	95.....	15.2	79
45.....	9.6	54	100.....	15.6	80
50.....	10.3	58	105.....	15.9	81
55.....	11.0	61	110.....	16.2	81.5

[1] From an article by L. M. Ellis, in the Forestry Quarterly, for Mar. 1, 1911.

Based on 100 trees.

TABLE 8.—*Average rate of growth, in diameter, of 50 representative jack pine trees, on the Riding Mountain Reserve, Manitoba, Canada.*[1]

Age.	Diameter breasthigh (outside bark).	Age.	Diameter breasthigh (outside bark).
Years.	*Inches.*	*Years.*	*Inches.*
10.....	0.5	60.....	10.1
20.....	2.8	70.....	11.0
30.....	5.4	80.....	11.7
40.....	7.3	90.....	12.2
50.....	8.8	100.....	12.6

[1] From Bulletin 6, "Wood-Using Industries of the Prairie Provinces," of Canadian Forestry Branch. This bulletin states that: "Jack pine in closed stands on the Riding Mountain Reserve reaches 60 to 80 feet in height by 12 to 18 inches in diameter, with straight, clear trunks yielding a good grade of saw and tie timber. But where open grown they are a mass of limbs right to the ground, and of little value, even for firewood.

Table 3, relating to trees grown in Cass County, Minn., shows a less rapid diameter growth than Table 2, which refers to other trees grown in the same county, probably because those covered in Table 3 are comparatively open grown, thrifty second growth.

Table 4 indicates the average dominant and the predominant growth on jack-pine land of good quality in the northern part of the Southern Peninsula of Michigan.

Tables 5 and 6 indicate the development of jack pine in dense stands on good sites in the southern part of the Upper Peninsula of Michigan.

Table 7 indicates the rate of growth on good sites in western Ontario, a region very favorable to the growth of jack pine.

Table 8 shows the growth on poorer soil in Manitoba.

Tables 9 and 10, which are not comparable with Table 1, being based on different data, show the average growth and yield at different ages of dense, even-aged, unmanaged stands of jack pine on sandy soils in Hubbard County, Minn. These stands have been more or less damaged at one time or another by ground fires which were not sufficiently severe to kill many trees, but which without doubt appreciably lessened the vitality and rate of growth of a large number of them.

TABLE 9.—*Rate of growth and yield per acre of pure, even-aged, densely stocked stands of jack pine in Hubbard County, Minn.*

SITE QUALITY "GOOD."

Age.	Trees per acre.			Average.			
				Basal area.	D. b. h.	Dominant height.	Yield per acre.[1]
	Total.	5 inches and over.	10 inches and over.	5 inches and over.	5 inches and over.		
Years.	*Number.*	*Number.*	*Number.*	*Sq. ft.*	*Inches.*	*Feet.*	*Cu. ft.*
20	1,120	94	.....	15	5.4	30	730
25	839	153	.....	28	5.8	37	1,090
30	672	281	.....	57	6.1	43	1,630
35	565	391	7	90	6.5	48	2,480
40	485	404	26	102	6.8	52	2,970
45	432	393	39	108	7.1	56	3,260
50	398	382	45	111	7.3	60	3,470
55	374	371	48	114	7.5	63	3,660
60	358	358	51	115	7.7	66	3,840
65	345	345	53	116	7.8	69	4,010
70	332	332	53	116	8.0	71	4,180

SITE QUALITY "POOR."

25	1,400	71	.....	10	5.1	29	660
30	1,091	138	.....	22	5.4	35	930
35	846	203	.....	36	5.7	40	1,250
40	698	279	.....	53	5.9	44	1,590
45	602	330	.....	67	6.1	48	1,900
50	537	360	.....	78	6.3	51	2,180
55	490	373	6	86	6.5	54	2,430
60	450	376	17	92	6.7	56	2,660
65	412	374	25	97	6.9	58	2,870
70	377	364	30	100	7.1	60	3,080

[1] Total volume, including bark, of all trees 2 inches and over in diameter, breast high.

Based on 128 plots; area, 90.2 acres. Measurements by H. H. Chapman.

TABLE 10.—*Yield per acre of pure, even-aged, densely stocked stands of jack pine in Hubbard County, Minn., calculated in cubic feet, cords, and board feet.*

Age.	Yield per acre.						
	Trees 5 inches and over.	Trees 5 inches and over.		Mill tally.[4]		Scribner Decimal C.[5]	
		With bark.[2]	Peeled.[3]	Trees 5 inches and over.	Trees 8 inches and over.	Trees 8 inches and over.	Trees 10 inches and over.
Years.	*Cu. ft.*[1]	*Cords.*	*Cords.*	*Board ft.*	*Board ft.*	*Board ft.*	*Board ft.*
SITE QUALITY "GOOD."							
20	160	1.6	1.3	500	.....	.....	.....
25	650	6.5	5.3	3,200	700	300	.....
30	1,360	13.6	11.2	6,900	1,900	700	.....
35	2,210	22.1	18.2	10,500	3,200	1,400	300
40	2,800	28.0	23.1	13,200	4,700	2,300	1,300
45	3,160	31.6	26.1	14,900	6,500	3,800	2,200
50	3,420	34.2	28.3	16,300	8,600	5,200	2,900
55	3,640	36.4	30.1	17,400	10,700	6,200	3,400
60	3,840	38.4	31.8	18,500	12,500	6,900	4,000
65	4,010	40.1	33.3	19,600	14,000	7,600	4,400
70	4,180	41.8	34.7	20,600	15,300	8,200	4,800
SITE QUALITY "POOR."							
25	130	1.3	1.1	700	.....	.....	.....
30	470	4.7	3.8	2,200	.....	.....	.....
35	870	8.7	7.1	4,000	.....	.....	.....
40	1,300	13.0	10.6	6,200	200	.....	.....
45	1,670	16.7	13.7	8,100	1,100	400	.....
50	1,990	19.9	16.3	9,600	2,200	800	.....
55	2,280	22.8	18.7	10,900	3,400	1,500	300
60	2,550	25.5	21.0	12,200	4,900	2,500	1,000
65	2,790	27.9	23.0	13,400	6,600	3,800	1,600
70	3,010	30.1	24.9	14,500	8,200	4,900	2,100

[1] Total volume of stem, including bark.
[2] 100 cubic feet equal 1 cord.
[3] Per cent of bark in total volume, 18.9 down to 16.9, decreasing with increase in age.
[4] Scaled by white-pine mill-cut table. See Table 27, in appendix.
[5] Stump height, 1 foot; diameter inside bark at top, 5.5 inches, scaled by Table 25 (appendix).

Based on plots given in Tables 34 and 35 in the appendix.

In these tables "good" quality of site indicates the better classes of soils which would be suitable for growing Norway pine, while "poor" quality indicates those soils not so well adapted to Norway pine.

Tables 34 and 35 (appendix) give the details of the field measurements of the plots used as the basis of Tables 9 and 10. All of these plots were used as a basis for determining the total cubic volume. The items other than total cubic volume were based on selected plots classified as qualities "good" and "poor" on the basis of their total cubic yield. This classification corresponds closely to a classification based on the average dominant heights of the different plots. (See fig. 3, facing p. 16.) The plots selected were those whose total cubic volumes were close to the average curves for total cubic volumes.

Table 11 shows the growth and yield of six plots at different points in northern Minnesota, the data having been collected and computed by State Forester Cox. Under the heading, "Quality of site,"

these plots are compared as to cubic-foot yield with those in Hubbard County (Table 9), and the site quality averages "poor." One plot at Cloquet, Minn., ranks somewhat higher than that given under site quality "good" in the Hubbard County yield table.

TABLE 11.—*Yield per acre of six sample plots in dense, even-aged stands of jack pine on sandy soil in northern Minnesota.*[1]

	Plot 1, Cloquet, age 13 years.	Plot 2, Cloquet, age 37 years.	Plot 3, Park Rapids, age 39 years.	Plot 4, Ferris, age 40 years.	Plot 5, Bemidji, age 62 years.	Plot 6, Cass Lake, age 66 years.
Total number of trees	10,464	586	800	460	180	252
Average diameter breast high, inches	1.5	6.5	5.4	5	10	9
Average total height.....feet..	16	48.5	44	48.5	67	70.5
Yield per acre.....cubic feet..	282.53	3,142.68	1,989	984.4	2,481	3,102
Yield per acre.....cords..	3.95	44	27.8	13.78	34.7	43.43
Yield per acre.....board feet..	1,978	21,999	13,925	6,891	17,367	21,715
Quality of site	[2] Poor.	[2] Good.	[2] Poor.	[2] Very poor.	[2] Poor.	[2] Poor.
Average annual increment, cubic feet	21.6	85	51	24.6	40	47
Average annual increment, cords	3	1.19	0.7	0.34	0.56	0.66
Average annual increment, board feet	152	593	357	172	280	330

[1] From data collected and computed by the Minnesota Forest Service in 1913.
[2] Compared with cubic-foot yields in Hubbard County, Minn. See Table 9.

Table 12 shows the growth and yield of 12 plots in typical stands in Adams County, Wis., on sandy soils covered with pure stands of jack pine. Under the heading, "Quality of site," these plots are compared as to cubic-foot yield with those in the Hubbard County yield table (Table 9), and the site quality easily averages "good," some of the plots ranking much higher than the site designated as "good" in Table 9.

TABLE 12.—*Stand and yield per acre of 12 sample plots in dense, even-aged stands of jack pine on sandy soil in Adams County, Wis.*

Age of plot.	Living trees per acre.						Average.		Basal area.		Total yield per acre.	Quality of site.[1]
		Jack pine.		Other species.								
	Total.	5 to 9 inches.	10 inches and over.	1 to 4 inches.	5 to 9 inches.	10 inches and over.	Diameter, breast high (5 inches and over).	Dominant height.	1 inch and over.	5 inches and over.		
Years.								*Feet.*	*Sq. ft.*	*Sq. ft.*	*Cu. ft.*	
23	530	280	.....	.....	.....	.....	5.6	32	62	48	949	Good.
25	950	460	.....	10	.....	.....	5.9	42	114	88	2,337	Very good +.
31	390	250	30	110	20	.....	7.6	45	96	87	1,995	Good +.
32	400	300	60	200	.....	.....	8.0	46	127	125	2,971	Very good.
32	490	370	40	70	.....	.....	7.5	48	131	127	3,085	Do.
34	416	344	8	184	24	.....	7.5	49	113	109	2,550	Good +.
36	410	310	20	60	50	.....	7.3	50	101	96	2,465	Good −.
40	336	272	56	24	.....	.....	7.9	50	113	113	2,572	Good −.
41	408	304	32	16	24	.....	7.5	53	110	104	2,686	Good −.
50	560	260	.....	240	30	.....	6.4	38	73	59	1,352	Very poor.
50	330	200	80	130	40	.....	8.8	50	120	118	2,834	Poor +.
50	300	190	90	30	40	.....	8.6	60	114	113	3,310	Good −.

[1] Compared with cubic-foot yields in Hubbard County, Minn. See Table 9.

Measurements by the author, 1917.

It is interesting to compare the growth and yield of unmanaged natural jack pine stands as shown in Tables 9 and 10, with the growth and yield of well-managed Scotch pine stands in Europe, as shown in Table 32 (appendix). In yield per acre the "good" quality site in the Hubbard County table averages between site qualities II and III for Scotch pine, and the "poor" quality site averages between IV and V. In the matter of height, the Hubbard County trees on sites whose quality is described as "good" and "poor" rank considerably higher than the Scotch pine trees on the above-mentioned sites. This may be partly accounted for by the fact that Table 9 gives the average dominant height, while Table 32 gives the average height of the stand. In general, however, a comparison of the greater heights and lesser yields of unmanaged jack pine stands with the lesser heights and greater yields of managed Scotch pine suggests the possibility of increasing the yield of jack pine by growing it under management.

Table 13 gives the average annual increment in cubic feet and board feet of the stands of different ages computed on the basis of volumes given in Tables 9 and 10.

TABLE 13.—*Mean annual increment of pure, even-aged, densely stocked stands of jack pine, figured in total cubic feet for trees 5 inches and over in diameter, in board feet mill scale for trees 5 inches and over and for trees 8 inches and over in diameter, and in board feet by Scribner log rule for trees 8 inches and over in diameter.*

Age.	Total.	Site quality good.				Total.	Site quality poor.			
		Mill scale.			Scribner.		Mill scale.			Scribner.
		5 inches and over.	5 inches and over.	8 inches and over.	8 inches and over.		5 inches and over.	5 inches and over.	8 inches and over.	8 inches and over.
Years.	*Cu. ft.*	*Cu. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Cu. ft.*	*Cu. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*
20	36	8	25	.....	.....	.....	.....	.....	.....	.....
25	44	26	128	28	12	26	5	28	.....	.....
30	54	45	230	73	23	31	16	63	.....	.....
35	71	63	300	114	40	36	25	91	.....	.....
40	74	70	330	155	58	40	32	118	5	.....
45	72	70	331	180	84	42	37	144	24	9
50	69	68	326	192	104	44	40	172	44	16
55	67	66	316	198	113	44	41	195	62	27
60	64	64	308	203	115	44	42	208	82	42
65	62	62	302	206	117	44	43	215	102	58
70	60	60	294	207	117	44	43	219	117	70

STANDARD SITES.

In figure 3 are exhibited all the available age-height data plotted in accordance with Prof. Roth's plan for site classification.[1] According to this plan all species whose dominant trees reach an average height of only 90 feet in 100 years on the best sites (to be called Site I for those species) are to be classified as standard C species, stand-

[1] See Forestry Quarterly, March, 1916.

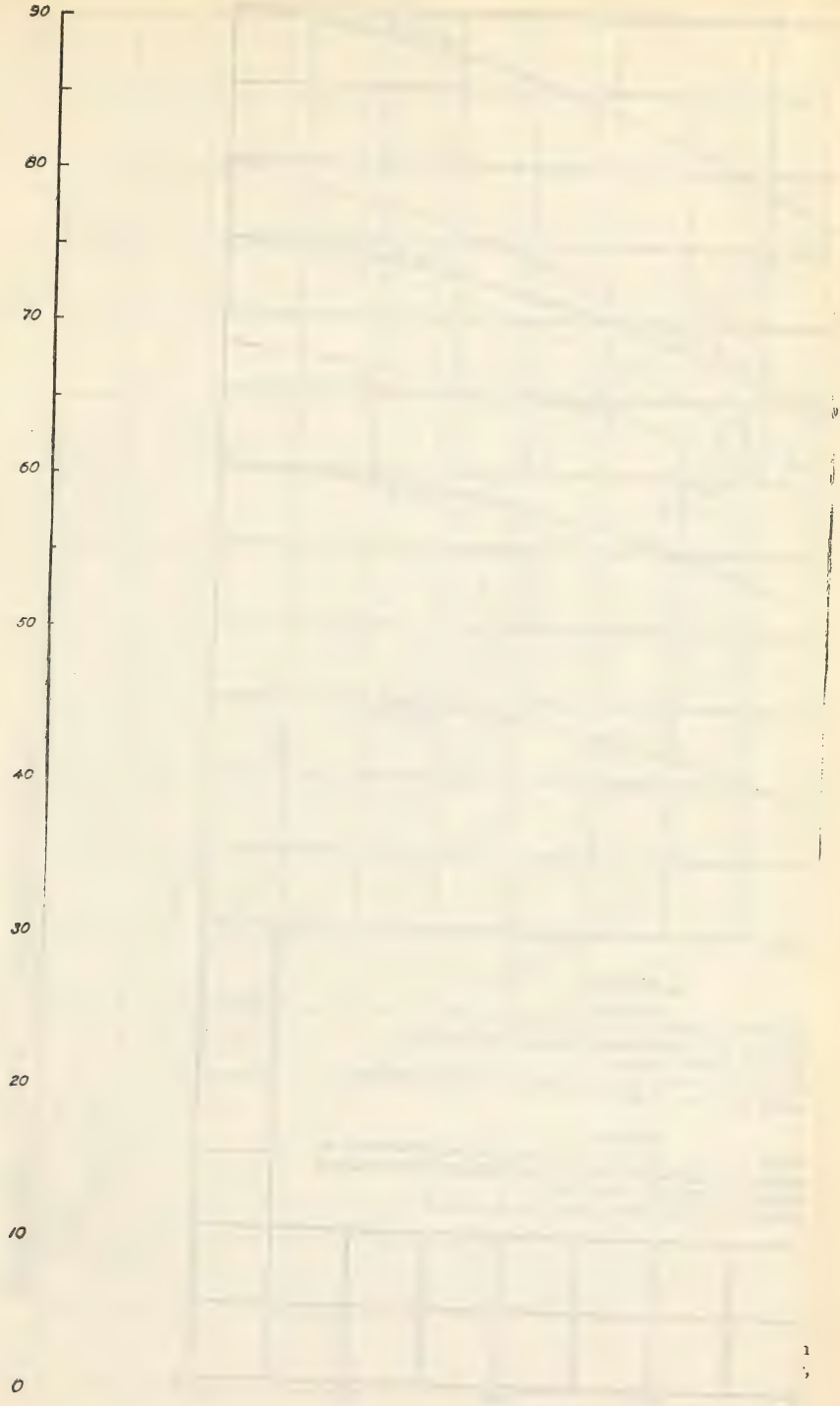


FIG. 3

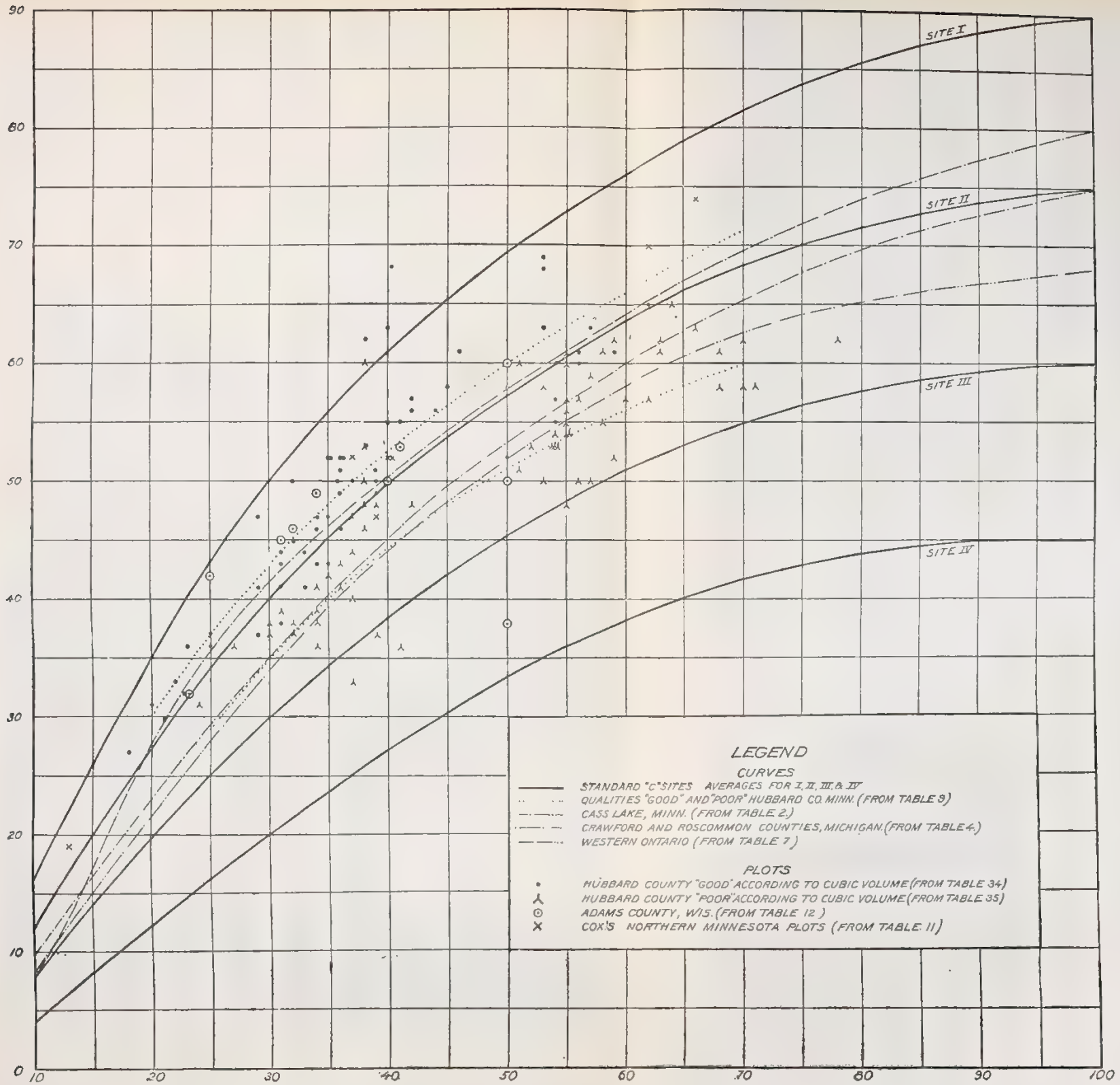


FIG. 3.—Jack pine age-height data and curves plotted with reference to Prof. Roth's plan for site classification standard C. Shows average height of dominant trees in stands of different ages.

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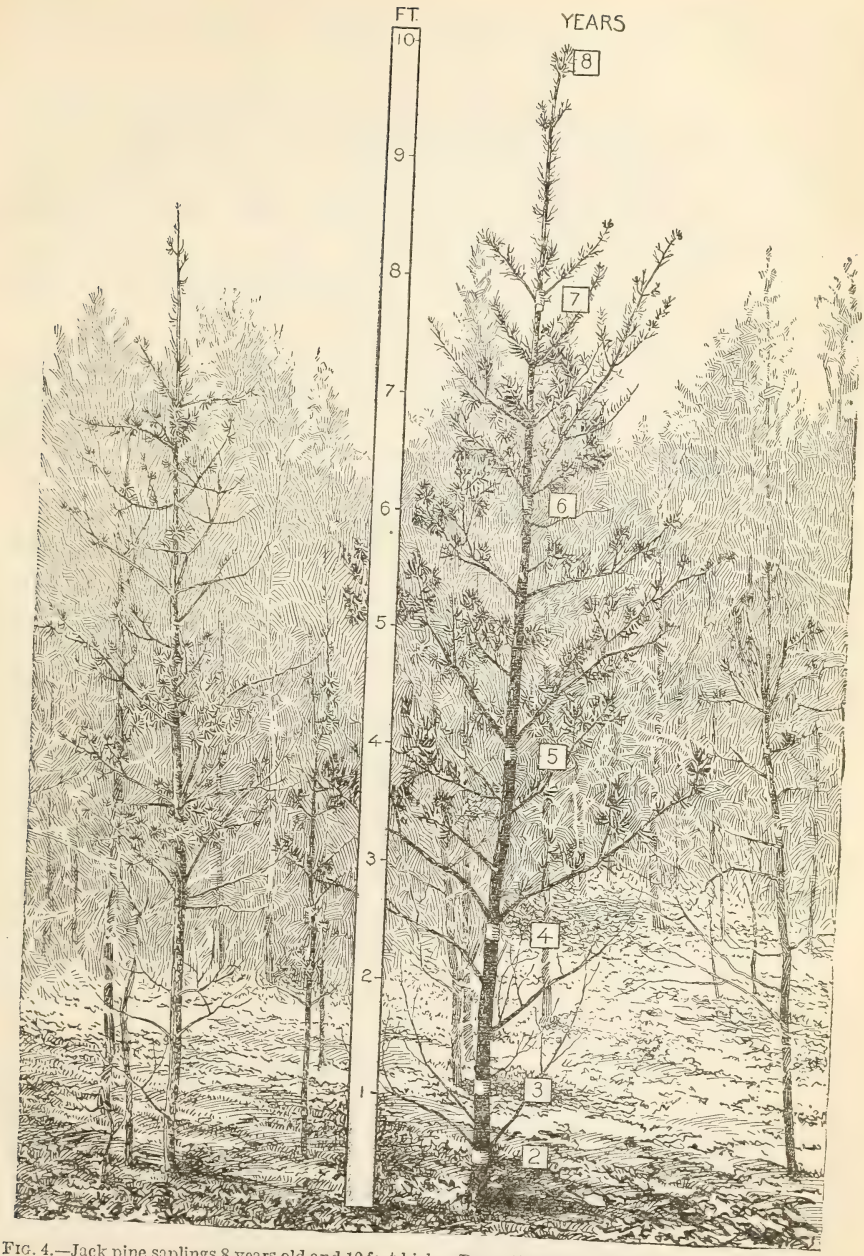

FIG. 4.—Jack pine saplings 8 years old and 10 feet high. Paper tied around nodes indicates termination of esch successive year's growth, and shows several whorls of lateral branches (usually 3) for each year, which is characteristic of this species.

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ards A and B being for higher-growing species. In a letter reviewing the manuscript on which this bulletin is based Prof. Filibert Roth says:

> I recommend that this standard of 90, 75, 60, and 45 feet for I, II, III, and IV sites be made a regularly accepted or adopted standard and called standard C, and that all species in the United States which have a growth near to jack pine have their sites established and measured by this same standard C site classification on the basis of height at 100 years, with values as given in figure 3, which works out well with data here gathered.
>
> Site I in older stands is represented sparingly in these studies (referring to the manuscript), because in Minnesota jack pine does not get a chance on Site I, since these run to Norway pine.
>
> Site IV is also little represented, but is abundant in Wisconsin and Michigan.

It will be seen that the "good" site in Hubbard County is slightly better than Roth's Site II, while the "poor" site is halfway between Sites II and III.

REPRODUCTION.

SEED PRODUCTION.

Jack pine produces a great quantity of seed. In view of the comparative shortness of the life of jack pine and its intolerance of shade, this characteristic is extremely important. As a matter of fact, the fruitfulness of jack pine, combined with its ability to grow on soils too poor, at the outset, for other species, is the means by which it is able to maintain itself as one of the most widespread and important forest types of the North. (See Pls. IX and X.) Jack pine, like lodgepole, is a "fire tree," quickly seeding up bare-burned spots or areas. It seeds well almost every year and heavily every two or three years, in contrast with Norway and white pines, which do not seed every year and which seed in abundance only at intervals of from five to seven years and three to five years, respectively. Trees in the open or with abundant growing space are the most prolific seeders and commence to bear seed when from 6 to 8 years old. Vigorous seed production continues up to 80 years of age, but is most vigorous between 40 and 80 years.

A well-developed, vigorous tree produces from 1,000 to 1,200 cones in a year, or from one-fourth to one-half bushel, and these cones contain from one-fourth to one-half pound of seed, each cone having from 25 to 50 seeds.[1] Very heavily loaded jack pines sometimes yield 1½ bushels of cones. There are from 75,000 to 100,000 seed per bushel of cones, and from 100,000 to 150,000 seed per pound. The cone matures the second year. The seed is ripe about September 1 and dissemination commences soon afterwards. During dry seasons many more cones open up than in wet. Nearly half of them

[1] Report of Cloquet, Minn. Experiment Station, October, 1917, gives an average of 30 jack pine seed per cone as compared with 37 seeds per cone in Norway pine.

persist on the tree for several years,[1] opening gradually under the drying effect of heat and wind. Many cones that are on the ground do not open at all until scorched by fire. The process of seed dissemination of jack pine is thus almost continuous.

The small, light, jack pine seed with its relatively large wing is readily disseminated to considerable distances. It is probable that light winds, which are of frequent occurence in the range of jack pine during the season of dissemination, carry some of the seeds for distances of a quarter of a mile or more; but most of the seeds undoubtedly fall within 100 yards of the parent tree.

QUALITY OF SEED.

Freshly gathered samples of jack pine seed have shown germinating percentages of 95 or 100.[2] Samples from cones that had remained closed for some time indicated a germination of from 60 to 75 per cent. Seed in well-closed cones may retain its germinating capacity many years. The great quantity of seed produced and the high average percentage of germination explain to a degree the widespread distribution of this hardy species and its rapid regeneration on burned lands.

ESTABLISHMENT OF SEEDLINGS.

Under average natural conditions jack pine seed requires from 2 to 4 weeks for germination. Good seed, however, will germinate in 8 days under very favorable conditions of heat and moisture. If it is moist enough, the poorest sand will make a seed bed. After a a few weeks development of the root system the seedling becomes drought-resistant.

Reproduction is most plentiful on bare soil in the open, where the germinating seed strikes quickly into the mineral soil. Jack pine reproduction is usually excluded by other trees, weeds, and underbrush from better classes of seed bed, such as have a layer of well-decomposed humus. But a fire that destroys these and bares the mineral soil gives jack pine an excellent chance. In fact, fire is usually a necessary precursor of very dense jack pine reproduction, especially on good sites, because it clears the seed bed and opens up old cones. Where jack pine seeds in after a fire it is usually able to hold its own against other species. In northern Minnesota, however, if birch or aspen seed in simultaneously with it on a better class of soil, they usually crowd it out.

Jack pine seeding after a fire commonly produces an overstocked stand. Such a stand when 6 feet high would have from 5,000 to 10,000 trees to the acre; but, on account of the intolerance of the species, this number would rapidly diminish, so that the danger of

[1] In the southern part of the range of jack pine in Wisconsin very few cones remain unopen on the trees.
[2] State Forester Schaaf, of Michigan, reports a 58 per cent germination for good, fresh seed.

stagnation is not very serious.[1] Under the shade of mature stands few jack pine seedlings appear, for their establishment and growth depend on their obtaining abundant light.

The rate of growth of seedlings, especially seedlings of intolerant species, has much to do with the success or failure of the species, since it determines the amount of light they will receive in competition with other vegetation. Compared with other northern pines, jack pine grows rapidly, sometimes 6 inches or more the first year, 18 inches the first two years, and 3 feet the first three years.[2] On the the average, 1-year seedlings are 2 inches, 2-year-old seedlings 6 inches, and 4-year seedlings from 1 to 3 feet high. These last are not always high enough, however, to compete successfully with hardwood seedlings, brush, and weed growths of many kinds which are abundant on good soils.

SUSCEPTIBILITY TO INJURY.

FIRE.

Up to the age of 60 or 70 years fire is the greatest source of damage to jack-pine stands. These stands, occurring as they do on dry, sandy soils, are especially liable to fire damage after leaf litter and dead twigs have accumulated for several years. Fires in dense young stands often become crown fires, which burn with great fierceness and destroy the entire stand. In older and more open stands ground fires occur, which kill a few of the trees and lessen the vitality and resistance of those left.

Jack pine resists fire better than Norway and white pines because it grows more rapidly in diameter and height during its early years, and the young trees of a given age have thicker bark.

WIND, FROST, AND SNOW.

Jack pine trees do not often suffer from wind-throw where soil conditions have helped to develop a deep-going root system. On shallow and wet soils, however, the root system is flat and the tree is very susceptible to wind-throw. Where the trunks are tall and slender or where the trees have been weakened by insects or disease, severe storms cause considerable breakage.

Jack pine is not especially susceptible to damage from frost and snow, but heavy snowfalls and ice storms cause some injury to young slender saplings growing in dense stands. In the plantations of Nebraska and Kansas jack pine sometimes suffers from those snow and hail storms which come late in May and break off the leaders or new terminal shoots.

---

[1] Supervisor H. C. Hilton, of the Michigan National Forest, reports a case of complete stagnation of jack pine, a 20-year old stand containing from 50,000 to 100,000 trees per acre of an inch or less in diameter. Such cases, however, are very exceptional.

[2] Jack pine grows 2 to 3 whorls of branches each year (see fig. 4), while white and Norway pines only grow one.

F–32805A

FIG. 1.—JACK PINE MOTHER TREE (9 INCHES IN DIAMETER BY 25 FEET IN HEIGHT) AND SEEDLINGS SPRUNG FROM IT (2 TO 8 FEET TALL).

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FIG. 2.—REPRODUCTION OF JACK PINE AND BUR AND BLACK OAK SPROUTS IN A STRIP CLEAR CUT SIX YEARS AGO.

F-31792

FIG. 1.—OVERMATURE JACK PINE ORIGINALLY GROWN IN DENSE STAND, BUT NOW OPEN THROUGH NATURAL THINNING, AND JACK PINE REPRODUCTION COMING UP UNDERNEATH. CROW WING COUNTY, MINN.

F-69122

FIG. 2.—REPRODUCTION OF JACK PINE AFTER CLEARING AND FIRES ON AN ABANDONED FARM IN THE JACK PLAINS REGION, MICHIGAN.

DISEASES.[1]

Jack pine stands are usually free of serious fungous diseases, but when they reach an age of from 60 to 90 years many of the trees become heart-rotted. The fungus that most often causes this condition is *Polyporus schweinitzii*, but *Trametes pini* is sometimes responsible for it.

The most common disease in jack pine is the gall-forming rust, *Cronartium cerebrum* (Peck) Hedgc. & Long. The injury done to young and old trees alike by this fungus is such that, in any system of forest management of jack pine, methods for its eradication should be considered. "It causes the death or early suppression of trees of tender years and seriously interferes with the development of more mature growth." [1]

The defect known as "witches' broom" is frequently present in jack pine crowns, especially in open stands on dry, sandy soils. This is a bushy growth of fine twigs from an affected point on a terminal shoot. The stimulus for this growth is probably furnished, in most cases, by some perennial fungus. The "witches' broom" precludes further development beyond the point of attack, and the increment of a badly infected tree falls off rapidly. The damage is not widespread, however, and in the aggregate is not serious.[1] Near the limits of its northern range the jack pine is subject to attacks by mistletoe, resulting also in the formation of "witches' brooms."

Several fungous saprophytes attack jack pine wood left in the forest and cause its quick decay. Dead trees usually become unsound within 2 or 3 years.

INSECTS.

Jack pine is rarely damaged by insects, except where the stand has been seriously weakened by fire, especially by fire occurring in the summer. According to Dr. A. D. Hopkins, of the Bureau of Entomology, United States Department of Agriculture, the living jack pine is often attacked and more or less seriously injured at the base and on the stems of saplings by bark weevils and bark beetles, on the buds and twigs by tip moths, and on the foliage by saw flies. The tip moth has attacked most of the jack pine in the plantations at Halsey, Nebr., reducing the height growth and causing minor crooks. The bark and wood of weakened, dying, and felled trees are subject to attack by the common wood-boring insects, which also cause pinhole and wormhole defects in the crude products.[2]

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[1] For a full discussion of the diseases of jack pine, see Bulletin No. 212, U. S. Department of Agriculture, "Observation on the Pathology of the Jack Pine," by James R. Weir, Forest Pathologist.

[2] Any evidence of serious injury to living trees or their products, known or supposed to be caused by insects, should be reported to a Federal or State entomologist with a request for advice as to the need of adopting measures for prevention or control.

SUPPLY OF JACK PINE TIMBER.

The largest supply of jack pine timber in the United States is in Minnesota, north of 46° of latitude. State Forester Cox in July, 1916, roughly estimated this supply at 5 billion board feet,[1] with 10 million cords of material obtainable from trees under 8 inches in diameter. He also stated it as his belief that jack pine in that State is probably growing more rapidly than it is being cut, although fires destroy annually a great deal of the young growth.

In 1898, Prof. Filibert Roth said [2] of the supply of jack pine in Wisconsin:

> At present it is not used to any extent, neither stumpage nor logs having real commercial value, except where used as fuel and for farm purposes. The stand of this pine, if taken down to 4 inches, is about 3½ billion feet, of which about half might be used for dimension stuff, while the rest could be employed as pulpwood.[3]

The supply of saw stuff has doubtless been considerably reduced since that time. With respect to trees suitable for cordwood and pulpwood, however, new growth has probably equaled the amount that has been cut in clearing and lumbering.

A recent compilation by the author of the Forest Resources of Michigan places the stand of possible jack pine saw timber at 1–1/5 billion board feet. There would be more than this much again of pulpwood. In New York and New England the stand of jack pine is negligible.

Bulletin 50 of the Canadian Forestry Branch contains an estimate for 1915 of from 7 to 8 billion board feet of jack pine timber in Manitoba, Saskatchewan, and Alberta.

The supply of jack pine is more nearly keeping pace with the annual cut than that of either Norway or white pine. On the one hand, the market for it is more limited because of the small size of its timber; and, on the other, it reproduces freely on cut-over or burned land formerly occupied by these more valuable species.

CHARACTERISTICS OF THE WOOD.

Superficially the wood of jack pine is similar to that of Norway and white pines. The sapwood is nearly white and the heartwood light brown to pale orange. In trees under 50 years of age the wood is mostly sap, the proportion gradually decreasing with age. Even in 100-year-old trees the sapwood often constitutes half the volume.

The wood is soft, light, a cubic foot of kiln-dried lumber weighing about 30 pounds, not strong nor tough, straight and rather coarse-grained, easily worked, easily split, and apt to warp and check in

[1] A recent compilation by the author of the forest resources of Minnesota places the stand at 2½ billion board feet.

[2] Bulletin 16, Division of Forestry, U. S. Department of Agriculture.

[3] The stand of jack pine saw timber 8 inches and over in Wisconsin is placed in a recent compilation by the author at 1¼ billion feet.

seasoning unless care is exercised. It is more resinous than white pine, but less so than the yellow pines of the South. The heartwood is fairly durable in contact with the ground, but the sapwood rots quickly.

A comparison of the mechanical properties of jack pine and other species is shown in full in Bulletin 556, United States Department of Agriculture.[1] That bulletin gives the results of tests which show lower average values for jack pine than for Norway pine in cross bending, stiffness, and work to the maximum load perpendicular to the grain, and higher values in compression parallel and perpendicular to the grain, in hardness, and in shearing strength. The differences, however, are not great. As compared with white pine, jack pine shows somewhat higher average values in all the above properties except in stiffness and in cross bending, in which white pine averages slightly higher.

The specific gravity of oven-dry jack pine wood, based on volume when green, is 0.39, which is intermediate between Norway at 0.44 and white pine at 0.36. The weight of a cubic foot of air-dried wood of jack pine is 29 pounds, that of Norway is 34, and that of white pine is 27 pounds.

The structure of jack pine wood, in gross and microscopic characteristics, is not conspicuously different from that of other hard pines.

UTILIZATION.

Jack pine is used for railway ties, lumber, slack cooperage, pulpwood, mine timbers, poles, fencing, and fuel. (See Pls. XI and XII.)

RAILWAY TIES.

The greatest consumption of jack pine for railroad ties is in Canada, where in 1911 jack pine [2] replaced cedar as the leading species used, and 5½ million jack pine ties (38 per cent of all ties purchased) were bought by consumers at an average price of 41 cents. In 1914, 8,379,064 jack pine ties, comprising 43.2 per cent of all ties bought, were purchased in Canada at an average price of 43 cents. In the Lake States jack pine is used much less for ties than for lumber.

Ties can not be produced from trees under 10 inches in diameter breast high. Therefore, the proportion of the total stand of jack pine from which ties can be cut is relatively small and only the older trees can be used. Table 28 (appendix) indicates the number of ties it is possible to cut from trees of different sizes, and Table 9 shows the number of trees 10 inches and over in diameter in fully stocked stands of different ages.

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[1] "Mechanical Properties of Woods Grown in the United States," by J. A. Newlin and Thomas R. C. Wilson, of the Forest Products Laboratory.

[2] Including some lodgepole pine (*P. contorta*) from Alberta and British Columbia.

Untreated jack pine ties last from 6 to 8 years because they are cut from comparatively old trees that have a large proportion of durable heartwood. An increasing proportion of jack pine ties, however, is being creosoted, and these treated ties last from 15 to 20 years if they are not sooner rendered unusable by frequent spiking.

LUMBER AND SLACK COOPERAGE.

The chief use for the larger jack pine trees in the Lake States is for lumber. Where jack pine occurs either with Norway or white pine it is always cut with these species just as it comes. The larger and better trees are utilized chiefly for construction material, boards, siding, and box and slack cooperage material.

In Minnesota [1] most of the big mills cut at least a small quantity of jack pine. Perhaps 200 small mills cut jack pine, and in some cases nothing else, for use as box lumber and grain door boards. The annual cut is perhaps 200 million feet, and the cost of logs at the mills, from $7 to $9 per 1,000 board feet.

In Wisconsin [2] all mills, from the smallest to the largest, cut jack pine. It would be very difficult to get a figure on the amount cut by large mills, and impossible to get any estimate on the amount cut by the small mills, because in many instances the good jack pine goes in with Norway pine lumber.

The cost of jack pine at a sawmill varies from $10 to $15 per 1,000 board feet, depending on the location, business conditions, and size of the timber. In 1917, No. 3 and better jack pine lumber sold for $20 per 1,000 f. o. b. Duluth, Minn.

In Canada jack pine comprises about 1 per cent of the total annual lumber cut. Table 14 shows the cut of jack pine and the f. o. b. mill value of the lumber in the different provinces for the years 1913 and 1914.

TABLE 14—*Lumber cut and f. o. b. mill value of jack pine in Canada.*[3]

Province.	No. of active mills reporting.	Quantity.		Average value per M feet b. m.	
		1913	1914	1913	1914
Total all provinces	497	*M ft. b. m.* 35,404	*M ft. b. m.* 44,000	*Dollars.* 14.37	*Dollars.* 14.23
Ontario	47	24,297	17,890	14.51	15.00
Quebec	400	1,160	13,727	16.00	14.00
British Columbia	10	4,306	7,041	14.29	12.51
Alberta	22	2,237	4,488	15.83	14.58
New Brunswick	2	358	400	13.64	14.06
Manitoba	8	2,783	201	11.71	14.05
Saskatchewan	4	206	146	12.00	12.00
Nova Scotia	3	51	105	16.20	14.95
Prince Edward Island	1	6	2	12.50	20.00

[1] Letter from State Forester Cox, of Minnesota, July 17, 1916.
[2] Letter from State Forester Moody, of Wisconsin, July 31, 1916.
[3] From Bulletin 56 of the Canadian Forestry Branch.

F–32823A

FIG. 1.—PORTABLE MILL OPERATION IN A 30 TO 40 YEAR OLD JACK PINE STAND. LOGS MOSTLY FROM 8 TO 10 FEET LONG BY FROM 4 TO 10 INCHES (AVERAGE 6) IN DIAMETER AT TOP END. SIXTEEN HUNDRED LOGS WERE ESTIMATED TO CUT 20,000 FEET, OR 80 LOGS PER 1,000 FEET. LOGS CUT MOSTLY INTO 2 BY 4 AND INCH BOARDS.

F–32817A

FIG. 2.—FORTY-YEAR-OLD STAND AFTER CLEAR CUT FOR PULPWOOD. SHOWS TREES TOO SMALL FOR PROFITABLE PULPWOOD CUTTING LEFT STANDING, BUT MOST OF WHICH WILL PROBABLY BE WIND-THROWN LATER ON.

Danger of fire here is great on account of the unpiled and unburned slash.

LUMBERING OF DENSE, EVEN-AGED, JACK PINE STANDS.

F-34758A

FIG. 1.—STAND BEFORE CUTTING.

F-34757A

FIG. 2.—STAND BEING CUT.

DENSE, EVEN-AGED, 40 TO 50 YEAR OLD JACK PINE STANDS OF PULPWOOD SIZE, TREES 3 TO 9 INCHES IN DIAMETER, WITH 20 TO 25 CORDS PER ACRE.

In general, where Norway pine logs average from $12 to $14 per 1,000 board feet delivered at the mill, jack pine will average about $8.[1] In the winter of 1917, in Minnesota, jack pine logs sold as high as $12 and Norway pine at $17. The difference in price paid for jack and Norway pine in the log may be due partly to the fact that jack pine logs are smaller than the Norway pine, running sometimes 40 or 50 logs to the thousand. Many of the trees from the older jack pine stands in Minnesota cut out better lumber than it is usually supposed can be cut from this tree. In some cases at least 50 per cent of the season's run of jack pine goes into No. 2 and No. 3 boards and No. 1 and No. 2 dimension stock. As such it brings the same price as Norway pine, and is, in fact, often graded as lower grades of Norway and white pine.

Young stands of jack pine, too small for saw logs, are utilized for small slack cooperage, box boards, and crating. The cooperage material is used for pails, kegs, barrel headings, and a small amount for silos. In Michigan jack pine is used to a limited extent for shingles. Lath plants use the trees in the form of short bolts down to 3 or 4 inches in diameter at the top end. Young stands often yield large returns both on account of the great number of trees per acre and of this close utilization of small trees.

The number of board feet, mill scale, as given in Table 10, indicates the possibility of close utilization of jack pine in producing round-edge lumber for box and crating material. This method of utilization is feasible where portable mills are employed in dense, even-aged stands, and in this way a high yield of low-grade material is obtained at a small cost.

PULP.

Jack pine is suitable for chemical pulps made by using alkaline cooking liquors, either sulphate or soda. In this process it takes 2 cords of wood to produce a ton of sulphate pulp.

Jack pine is used for sulphate or kraft pulp in Michigan, Wisconsin, Quebec, and Ontario. In Quebec, in 1914, 16,746 cords of jack pine, at an average cost of $6.20 delivered, were used by three sulphate mills, while in Ontario in the same year 7,969 cords at $4 were used by one mill. There are three sulphate plants in Wisconsin and one in Michigan, and the outlook is good for additional plants of this kind in Canada and the Lake States. These plants should open up extensive markets for young second-growth jack pine trees too small

[1] The following statement from a January, 1920, report of the supervisor of the Minnesota National Forest indicates how greatly prices and costs have changed since the above was written:

"A sale of standing jack pine timber on that Forest, made in 1919, brought $6.30 per 1,000 board feet for live and $3.15 for dead timber. The cost of logging this timber was about $20 per 1,000 feet, making a total cost of $23.15 to $26.30 for jack pine logs delivered on the landing, or double the cost of what white pine logs were 10 years ago. A few years ago, when the jack pine timber could have been logged for $5 to $8 per 1,000 feet, there was no sale for it."

for ties or lumber. In Wisconsin $5 per cord is the usual price paid for jack pine with bark left on delivered at the railroad. It costs the pulp mills about $8 per cord, delivered.

Jack pine is used somewhat for ground wood pulp. "When combined with large proportions of sulphite jack pine ground wood pulp produces a satisfactory manila of a color other than white."[1] The Forest Products Laboratory is confident, from its experiments, that ground wood pulp from jack pine can be used in proportions well worth while in the manufacture of newsprint.

One of the big problems in the pulp industry in the Lake States is the obtaining of a supply of woods which can be converted at a reasonable cost into sulphite and ground wood pulp for newsprint paper, and which shall be accessible to the expensive plants already established. If jack pine can be used, the problem will be solved to a large extent for many of the established plants, because of the large supply of this wood in sizes suitable for pulp, its prolific reproduction, and its rapid growth. If the present prices for newsprint paper continue, methods will probably be developed which will make jack pine and other pines available for newsprint.

FUEL.

In many parts of its range, jack pine is the principal fuel, coal being scarce and its use limited. The estimated quantity of firewood used annually in the Lake States on farms alone is over 6,500,000 cords, and of this amount jack pine forms a large percentage. In many towns of 2,000 population and over the annual consumption is 2,500 cords and upward. Many of the local light and power companies use this species exclusively.

MINE TIMBER.

Jack pine in the round is used in considerable quantities in the Lake States for mine props, posts, and lagging. In northern Minnesota, jack pine timbers bring $18 per 1,000 feet Scribner Decimal C log scale, without cull for defects of any kind, f. o. b. main-line railroads.

POSTS AND POLES.

Considerable jack pine is used for posts, and, in the absence of better species, quite a little for short poles, from 20 to 30 feet in length. For these purposes it is particularly serviceable if it is well seasoned and painted with creosote or some similar preservative. The untreated timber does not last well in contact with the soil.

[1] From Bulletin 343, U. S. Department of Agriculture, on "Ground Wood Pulp," by Thickens and McNaughton.

STUMPAGE VALUES.

Jack pine saw logs bring from $8 to $15 per 1,000 board feet delivered at the mills in the Lake States, and the stumpage is worth from $2 to $8 per 1,000, depending on the distance from the mill and the means of transportation. This is for logs 6 inches and over in diameter at the small end, scaled by log-rule measurement. Jack pine trees over 10 inches in diameter can often be most profitably cut into railroad ties or into poles, for which purposes its stumpage is worth from $5 to $10 per 1,000 board feet. Where close utilization for lath, boxes and crating, slack staves, and slats is practiced, jack pine stumpage is worth from $1 to $5 per 1,000 feet of material actually cut out. For pulpwood, posts, and cordwood, where there is a market, jack pine is worth from 50 cents to $2 per cord, depending on its location.

TABLE 15.—*Stumpage values per acre of dense, even-aged stands of jack pine on site qualities "good" and "poor," figured for different values per cord and per 1,000 board feet.*

SITE QUALITY "GOOD."

Age.	Stumpage value per cord[1] of unpeeled wood.				Stumpage value per 1,000 board feet.					
					Mill scale.[2]			Scribner Decimal C.[3]		
	$0.50	$1.00	$1.50	$2.00	$1.00	$3.00	$5.00	$4.00	$6.00	$8.00
Years.										
20	$0.80	$1.60	$2.40	$3.20	$0.50	$1.50	$2.50	.....	.....	.....
25	3.25	6.50	9.75	13.00	3.20	9.60	16.00	$1.20	$1.80	$2.40
30	6.80	13.60	20.40	27.20	6.90	20.70	34.50	2.80	4.20	5.60
35	11.05	22.10	33.15	44.20	10.50	31.50	52.50	5.60	8.40	11.20
40	14.00	28.00	42.00	56.00	13.20	39.60	66.00	9.20	13.80	18.40
45	15.80	31.60	47.40	63.20	14.90	44.70	74.50	15.20	22.80	30.40
50	17.10	34.20	51.30	68.40	16.30	48.90	81.50	20.80	31.20	41.60
55	18.20	36.40	54.60	72.80	17.40	52.20	87.00	24.80	37.20	49.60
60	19.20	38.40	57.60	76.80	18.50	55.50	92.50	27.60	41.40	55.20
65	20.05	40.10	60.15	80.20	19.60	58.80	98.00	30.40	45.60	60.80
70	20.90	41.80	62.70	83.60	20.60	61.80	103.00	32.80	49.20	65.60

SITE QUALITY "POOR."

25	0.65	1.30	1.95	2.60	0.70	2.10	3.50	.....	.....	.....
30	2.35	4.70	7.05	9.40	2.20	6.60	11.00	.....	.....	.....
35	4.35	8.70	13.05	17.40	4.00	12.00	20.00	.....	.....	.....
40	6.50	13.00	19.50	26.00	6.20	18.60	31.00	.....	.....	.....
45	8.35	16.70	25.05	33.40	8.10	24.30	40.50	1.60	2.40	3.20
50	9.95	19.90	29.85	39.80	9.60	28.80	48.00	3.20	4.80	6.40
55	11.40	22.80	34.20	45.60	10.90	32.70	54.50	6.00	9.00	12.00
60	12.75	25.50	38.25	51.00	12.20	36.60	61.00	10.00	15.00	20.00
65	13.95	27.90	41.85	55.80	13.40	40.20	67.00	15.20	22.80	30.40
70	15.05	30.10	45.15	60.20	14.50	43.50	72.50	19.60	29.40	39.20

The stumpage values assumed in the above calculations are such as are being paid in the Lake States to-day, or may reasonably be expected to be paid in the near future.

[1] With bark. [2] All trees 5 inches and over. [3] Trees 8 inches and over.

TABLE 16.—*Cost per acre of growing jack pine, figured for $2, $5, and $8 initial investment, including cost of land and cost of planting, if any, at compound interest.*

AT 6 PER CENT COMPOUND INTEREST.

Age.	Cost per acre, at 6 per cent compound interest.			Cost per acre, at 3 per cent compound interest.		
	$2.	$5.	$8.	$2.	$5.	$8.
Years.						
20	$8.98	$19.72	$30.44	$5.49	$11.72	$17.94
25	12.42	26.95	41.47	6.74	14.12	21.49
30	17.02	36.63	56.23	8.18	16.90	25.60
35	23.17	49.57	75.98	9.86	20.12	30.37
40	31.40	66.91	102.41	11.80	23.85	25.90
45	42.42	90.09	137.78	14.05	28.18	42.30
50	57.16	121.13	185.10	16.67	33.20	49.73
55	76.89	162.67	248.45	19.69	39.02	58.35
60	103.30	218.25	333.22	23.19	45.77	68.33
65	138.63	292.64	446.65	27.26	53.58	79.90
70	185.91	392.19	598.45	31.98	62.65	93.32

The following is allowed for annual expenses in the above calculations: Five cents per acre for administration and protection, plus 1 per cent of initial cost for taxes, at 6 per cent or 3 per cent compound interest. This amount is added to the cost of the initial investment to date.

MANAGEMENT.

SUITABILITY OF JACK PINE FOR MANAGEMENT.

Jack pine is well suited for forest management for three reasons: (1) It thrives on poor soils; (2) it quickly reproduces itself after lumbering and fire, forming pure, densely stocked stands; and (3) it grows rapidly in its early years and soon attains sizes suitable for pulpwood, box boards, crating, small-dimension lumber, mine timbers, and slack-cooperage staves and heading. Its good growth on poor soils, unsuited to agricultural crops or on which more valuable kinds of tress do not readily seed up, suggests the possibility of utilizing large tracts of land which would otherwise be unproductive. The probability of this class of lands coming more and more under State or Federal control increases the importance of jack pine as a tree for forest management on a large scale.

Jack pine quickly seeds up poor soils and burned-over areas and makes them productive much sooner than would otherwise be the case. The more valuable Norway and white pines gradually seed in under the shelter of jack pine stands when the soil conditions improve. Wherever there is Norway or white pine reproduction underneath it to take its place, the jack pine should be eliminated after it reaches merchantable size.

Where jack pine occurs in mixture with Norway pine or other more valuable species on soils well suited to these latter, the natural reduction of jack pine that takes place with the increasing age of the stand should be allowed to go on. In some cases it may be advisable to reduce the proportion of jack pine by one or more cuttings to encourage the more valuable Norway pine in restocking the area and afterward to supplement the natural reproduction with

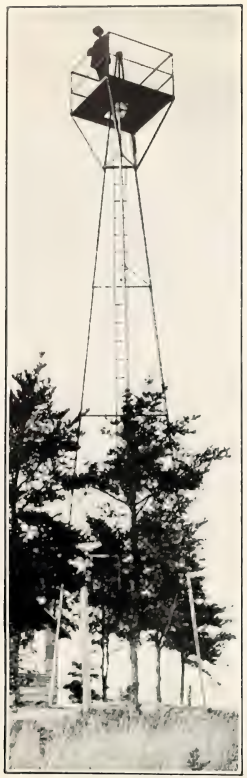
F–38621A

FIG. 1.—HIGH STUMPS CUT AS GUIDES IN LINING OUT FIRE LINE. THESE ARE REMOVED LATER SO THAT FURROWS CAN BE PLOWED.

F–27413A

FIG. 2.—A COMPLETED FIRE LINE, SHOWING PLOWED FURROWS WITH THE LIGHT, SANDY SOIL EXPOSED.

CONSTRUCTION OF FIRE LINES IN JACK PINE.



F-34731A

FIG. 1.—THE BEST TYPE OF LOOKOUT TOWER.

It cost $125. One of these is sufficient for each 40,000 acres.

F-38031A

FIG. 2.—STAND OF JACK PINE TOTALLY DESTROYED BY FIRE, LOWER PENINSULA OF MICHIGAN.

The land has been planted to Norway pines, set in plowed furrows, spaced 8 feet apart and 8 feet between furrows.

a planting of Norway pine. Similarly, it will often be advisable to plant Norway or white pine on vacant areas where the soil is suitable, which otherwise might become seeded up to jack pine by natural reproduction, as is being done in parts of Michigan. On poorer soils, however, where Norway or white pine has a poor chance of success, natural jack pine reproduction should always be encouraged.

The possible returns in growing jack pine may be estimated from Table 15, which gives the stumpage value per acre at different ages, figured for different values per cord and per 1,000 board feet, taken in connection with Table 16, which gives the cost per acre of growing such stands. Thus, on "good" quality jack pine land the stumpage value per acre of a 40-year-old stand at $1 per cord amounts to $28, as shown by Table 15. Reference to Table 16 shows that in 40 years, with money at 6 per cent and with an original investment of only $2 per acre, at which cost it would very rarely be possible to secure adequately stocked stands, the cost would be $31.40, or $3.40 more than the stumpage value. On the other hand, money at 3 per cent would admit of an original cost of $8 per acre and give a profit of $2.10 per acre above the 3 per cent interest earned on all money invested. In general, raising jack pine is at present a losing investment as compared with other investments at 6 per cent, but a very good one as compared with others at 3 per cent. At this latter rate of interest the State or Federal government would be fully justified in growing it on lands unsuited to agricultural crops or to more valuable species of trees.

ROTATION.

A short rotation for jack pine is the most practicable for securing the best financial returns and the reproduction of a new stand with the least difficulty. A comparison of Tables 14 and 15 indicates the financial advisability of a short rotation. Thus, with a stumpage value of $5 per 1,000 board feet mill scale, and with $5 original investment at 6 per cent on "good" quality of jack pine land, the best financial rotation appears to be around 35 years. When trees are of this age the stumpage value would be $52.50 per acre, and the cost, at 6 per cent interest on all money invested, only $49.57.

On lands under public control, where the financial return is secondary to the object of making otherwise waste land productive, a rotation of 60 years may be advisable, which would allow the production of ties and lumber as well as mine timbers, box boards, and pulpwood.

PROTECTION.

Since fires, even if not severe enough to kill the trees outright, practically always damage stands by impoverishing the soil, injuring and weakening individual trees, and reducing their resistance to

insects and fungi, the subject of fire protection is of prime importance in management. Reasonable assurance of protection is necessary before any expense in planting or management is warranted. To be adequate, the plan for fire protection should include provisions for patrol during the seasons when fire is a menace, the establishment and maintenance of fire lanes, the disposition of the slash resulting from thinnings or logging, and, on large tracts, lookouts and telephones. (See Pls. XIII and XIV.) An accumulation of logging slash is a menace to any live timber near it, not only because of its inflammability, but also because it may harbor destructive insects. Brush may best be disposed of by burning. Cutting in the fall and winter and burning the slash in piles as the logging proceeds is an effective preventive of insect infestation. Fire lanes, properly laid out, could be used in many cases as a means of dividing the forest into cutting series or blocks for utilization purposes and these lands would make one block accessible without slashing into another adjacent to it.

Danger from windfall may be lessened by cutting first on the lee side and proceeding in the direction from which the prevailing winds blow. In this way the interior of the stand is not opened to the sweep of the wind. Also, a short rotation will involve less windfall than a long one.

NATURAL REPRODUCTION.

The cutting of jack pine stands to encourage natural reproduction of the species may be accomplished in either one of two ways. The first method is that of clean cutting the mature stand either in strips or patches 100 yards or less in width. Reproduction would then take place from seed already on the ground or blown from the adjacent woods. The second method is that of a general clean cutting, leaving only from 5 to 10 scattered seed trees to the acre or, preferably, 2 or 3 groups of from 3 to 5 trees each. (See Pl. IX.)

To make sure of getting jack pine reproduction on the National Forests in northern Minnesota, it is sometimes considered necessary to lop the tops of the trees that have been cut and scatter the brush, which is burned in the spring as soon as it is dry enough. This causes cones on the ground to open and let out their seed. Also, the seedbed is prepared by the partial exposure of the mineral soil. On shallow soils with rock near the surface, brush should be burned in winter while snow is on the ground, so that the soil covering will not be disturbed. Fires should always be carefully controlled and be kept away from seed trees and adjacent timber Where overstocking of jack pine results, as is common after fires, the stand may be thinned out at a minimum expense within the first five years after the reproduction takes place. Natural reproduction and thinning would be less expensive than planting.

On the Michigan National Forests fire is not considered necessary in order to secure natural reproduction. This is because poorer soil conditions are found here than in northern Minnesota, and there is a much less vigorous growth of popple and white birch. The general policy here is to cut all merchantable trees, pile and burn the brush, and rely for reproduction on the seed that is already on the ground, or that may come either from the trees left after cutting or from trees on adjacent uncut areas.

PLANTING AND SOWING.

The cost of planting jack pine nearly equals that for white and Norway pines. Therefore, the extensive planting of this species does not seem warranted except on the poorest soils where these better trees will not grow. Even here, the ease with which natural reproduction is secured makes planting unnecessary in the majority of cases. For forest planting on relatively arid soils both inside and outside its natural range, for windbreaks, and for the fixation of moving sand, jack-pine may be the best tree to use. On severe exposures in the sand hills of Nebraska, for example, jack pine plantations have been eminently successful, while those of Scotch, Norway, and western yellow pines, Douglas fir, and arborvitæ have failed. (See Pl. XV.)

The recently adopted policy of the Public Domain Commission of Michigan provides for the planting each year of from 4,000 to 5,000 acres of waste sandy-plains land to forest trees, of which the State Forester[1] says from 20 to 33 per cent will probably be jack pine. It is here to be used largely as a filler for Norway and white pines, and planted from 5 to 6 feet apart in ploughed furrows, with 6 feet between the furrows. The National Forests in Michigan and Minnesota contain large areas of jack pine land. Wherever jack pine reproduces naturally, the Forest Service is glad to have it do so and in this way save the expense of planting. But the present Forest Service practice is not to plant jack pine on vacant land on these Forests, as it is believed none of this land is too poor to grow the much superior Norway pine. (See Pl. XIV, fig. 2.)

Nursery-grown stock is almost always used in planting out, wild stock being only occasionally collected for this purpose. Experimental planting of jack pine shows that on poor sites, such as those found in the sand hills of Nebraska, the best results are obtained from the use of 3-year-old stock which has been two years in the seed bed and one year in the transplant bed. This material can be raised at a cost of from $3.50 to $4 per thousand, including seed, preparation of beds, and subsequent care, while the collected wild stock costs about $5 per thousand. On Michigan State forests, however, good success has been secured from planting 2-year seed-

[1] Marcus Schaaf.

lings, and this was done at a total cost of $6 or less per acre for stock and planting. The State Forester [1] says:

> Two-year seedlings are so much cheaper than transplants, both as to material cost and labor of planting, and the death rate in plantations made with them is so small that we do not think that the increased cost of transplants is justifiable in planting on a large scale.

The most favorable time for planting in the spring is from the middle of April to the middle of May, and in the fall during the months of September and October.

The artificial establishment of jack pine stands by sowing the seed broadcast over the proposed site has been attempted, but, although the experiment was tried under many different conditions, it never met with much success. These experiments included spring and fall sowing and broadcasting on the snow in late winter. Some of the seeds germinated and became quite thrifty plants early in the spring, but were killed by the excessive heat during June and July.

The results of sowing and planting experiments in the northern half of the Lower Peninsula of Michigan indicate that planting home-grown nursery stock, and, in exceptional cases, thrifty 2 to 3 year old wild stock, promises the most satisfactory results.

THINNINGS.

The future value of dense young stands of jack pine may be greatly increased by thinning out the less promising and releasing the large and promising trees from competition for light and soil moisture, and in this way concentrating the growth energy of the stand into a smaller number and the best trees. In many cases some of the better trees should be cut, where these grow too close together, in order to establish a uniformly thinned stand, with the crown of each tree practically free on all sides, or barely touching its neighbors.

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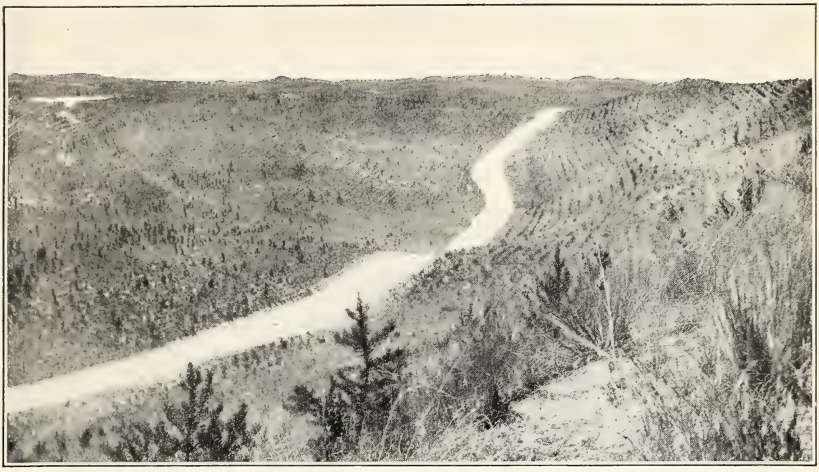
[1] Marcus Schaaf.



F–37557A

FIG. 1.—FIVE-YEAR-OLD JACK PINE PLANTATION TO RIGHT OF FIRE LINE, AND 9 TO 11 YEAR OLD YELLOW PINE PLANTATION TO THE LEFT OF FIRE LINE, IN THE DISMAL RIVER DIVISION OF THE NEBRASKA NATIONAL FOREST.

Jack pine survived and grew on more severe exposures where Scotch, Norway, and western yellow pines, Douglas fir, and arborvitæ failed.

F–22159

FIG. 2.—FIFTEEN-YEAR-OLD PLANTATION IN HOLT COUNTY, WHERE REAL FOREST CONDITIONS HAVE BECOME ESTABLISHED.

PLANTATIONS OF JACK PINE IN THE SAND HILLS OF NEBRASKA.

F-64794

FIG. 1.—EXTERIOR VIEW.

F-64795

FIG. 2.—INTERIOR VIEW.

DENSE 20-YEAR-OLD STAND OF JACK PINE ON CLAY SOIL IN NEED OF THINNING. HUBBARD COUNTY, MINN.

Table 31 (appendix) gives the yields obtained from thinnings of well-managed stands of Scotch pine in Europe. A comparison of these with the final yields given in Table 30 indicates cumulative intermediate returns, on quality III or average sites, of 5 to 40 per cent on any rotation between the ages of 30 and 50 years, inclusive. Similar results could probably be secured from the management of jack pine where the market conditions were favorable for utilizing the product of such cuttings.

Instead of clean cutting young jack pine stands for cordwood, as is often done, owners would do well to get their firewood by thinning their stands and allow the better trees to remain and produce a crop of timber valuable for purposes other than fuel. Jack pine stands should preferably be thinned as early as 20 years of age. (See Pl. XVI.) Thinnings to be effective should be severe, leaving the crowns of the trees fully isolated on all sides for a space of 5 to 10 feet. There would be considerably more danger from windfall and windbreak to trees left after severe thinnings in older stands than in younger—an important reason for thinning before the stand is 25 years old.

Very dense, overstocked sapling stands, from 6 to 8 feet high and from 5 to 6 years in age, such as are liable to stagnate, can be beneficially thinned by clearing of parallel lanes about 6 feet wide at from 8 to 12 foot intervals through the stand, and also thinning out trees in the rows to be left, or the stand may be thinned in two series of clear-cut parallel lanes at right angles to each other. From 800 to 1,200 trees to the acre, or 5 to 7 to the square rod, is a sufficient number to leave after thinning, provided some trees are left on every square rod of area and no large gaps are made in the stand. The saplings cut should be dragged out of the thicket and burned as a fire-protective measure and to prevent insects from breeding in the slash.

Clearing of lanes in overstocked sapling stands from 3 to 5 feet in height could be accomplished with greater ease than in taller stands, as brush scythes and brush hooks could be used, but would be inadvisable on poor dry soils where the establishment of a soil cover and good humous conditions are important. Lanes cut in such stands should, in general, be about the same width as the height of the stand.

APPENDIX.

BIBLIOGRAPHY.

DATA ON WHICH THIS BULLETIN IS BASED.

(1) Field measurements in Forest Service files.

Author.	Location.	Year.	Number taken.
Stem analyses:			
Chapman, H. H	Hubbard County, Minn.	1905	606 analyses of trees 2 to 17 inches in diameter.
Benedict, J. St. J	Cass County, Minn.	1912	52 analyses of trees 7 to 16 inches in diameter.
Sherrard, T. H	Roscommon and Crawford Counties, Mich.	1901	150 analyses of trees 3 to 13 inches in diameter.
Sample plots:			
Chapman, H. H	Hubbard County, Minn.	1905	128 plots, 90.2 acres.
Sterrett, W. D	Adams County, Wis	1917	12 plots.
Valuation surveys:			
Sherrard, T. H	Roscommon and Crawford Counties, Mich.	1901	100 acres, "Jack pine plain."

(2) Manuscripts in the Forest Service files.

"Report on the Study of Tie Production for the Northern Pacific Railroad," by Prof. H. H. Chapman, 1905.

"Jack Pine," by J. St. J. Benedict, 1914.

"Silvical Study of the Jack Pine," by L. L. White, 1906.

"Reforestation Policy for the Michigan and Marquette National Forests," by R. Zon, 1911.

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Silvical Report, Michigan National Forest, by W. B. Piper, 1912.

Silvical Report, Superior National Forest, by J. A. Fitzwater, 1912.

"Jack Pine," by C. A. Cecil, of the Superior National Forest, 1918.

(3) Publications.

"Jack Pine," Silvical Leaflet 44, Forest Service, 1909.

"Jack Pine in Western Ontario," by L. M. Ellis, in Forestry Quarterly, March, 1911.

Report of the Michigan Forestry Commission, 1902, in articles by T. H. Sherrard, Prof. Filibert Roth, and others.

"Forestry Conditions in Wisconsin," by Filibert Roth, Bulletin 16, Division of Forestry, U. S. Department of Agriculture.

Bulletins of the Canadian Forestry Branch.

TABLES.

TABLE 17.—*Proportion of the occurrence of jack, Norway, and white pine stands on different soils in northern Minnesota classified according to the prevailing size of their soil particles.*[1]

Class of soil.	Jack pine stands.	Norway pine stands.	White pine stands.
	Per cent.	*Per cent.*	*Per cent.*
Fine gravel, 2.0 to 1 mm	1.1	0.4	0.0
Coarse sand, 1 to 0.5 mm	61.0	3.7	3.3
Medium sand, 0.5 to 0.25 mm	30.3	12.0	4.6
Fine sand, 0.25 to 0.1 mm	3.3	62.9	16.2
Very fine sand, 0.1 to 0.05 mm	3.7	11.5	43.4
Silt, 0.05 to 0.005 mm	1.9	6.7	26.1
Clay, 0.005 mm	1.7	2.8	6.4
Total	100.0	100.0	100.0

[1] From unpublished preliminary report on Norway pine in Minnesota by H. H. Chapman. Based on mechanical analysis by the Bureau of Soils of a large number of soil samples from different jack, Norway, and white pine stands.

TABLE 18.—*Average width of crowns of predominant jack-pine trees of different ages and diameters, with enough light for good crown development, and growing in comparatively dense, even-aged stands.*

[Measurements by H. H. Chapman in Hubbard County, Minn., 1905.]

Age.	Site quality "good."			Site quality "poor."		
	Average diameter breast high.	Width of crown.	Basis.	Average diameter breast high.	Width of crown.	Basis.
Years.	*Inches.*	*Feet.*	*Trees.*	*Inches.*	*Feet.*	*Trees.*
10	1.8	7	.....	1.1	3	.....
20	5.5	11	1	3.9	6	.....
30	7.9	14	9	5.9	9	5
40	9.4	16	38	7.4	11	19
50	10.8	18	18	8.7	12	3
60	12.0	22	4	9.9	14	35
70	.....	.....	.....	10.9	15	13
80	.....	.....	.....	11.8	16	8
90	.....	.....	.....	.....	18	5
100	.....	.....	.....	.....	19	1
110	.....	.....	.....	.....	22	.....
120	.....	.....	.....	.....	24	.....
130	.....	.....	.....	.....	27	2
			70			91

TABLE 19.—*Double bark thickness, at diameter breast high, of jack pine in Minnesota.*

Diameter breast high.	Hubbard County, Minn.				Cass County, Minn.	
	Trees in dense stand.		"Isolated" or partly "isolated" trees.	Basis.	Bark.	Basis.
	Bark.	Basis.	Bark.			
Inches.	*Inches.*	*Trees.*	*Inches.*	*Trees.*	*Inches.*	*Trees.*
2	0.23	15	.....	.....	.....	.....
3	.30	28	.....	.....	.....	.....
4	.38	66	.....	.....	0.39	.....
5	.46	75	0.49	3	.43	.....
6	.54	80	.61	8	.47	.....
7	.63	85	.72	9	.52	1
8	.72	57	.84	13	.56	4
9	.82	47	.94	7	.61	8
10	.92	43	1.05	5	.67	16
11	1.03	22	1.15	7	.73	7
12	1.14	13	1.25	4	.80	10
13	1.26	6	1.34	1	.87	3
14	1.37	6	1.43	1	.94	1
15	1.48	1	1.51	.....	1.02	1
16	1.59	2	1.59	2	1.09	1
17	1.70	3	.....	.....	1.17	.....
18	1.79	.....	.....	.....	1.25	.....
19	1.87	.....	.....	.....	1.33	.....
20	1.94	.....	.....	.....	1.41	.....
		549		60		52

TABLE 20.—*Average thickness of bark at different heights above the ground in predominant jack pine trees in Hubbard County, Minn.*

[Trees 22 to 102 years old. Measurements by H. H. Chapman, 1905.]

Diameter breast high.	Height above ground (feet).								Basis.
	1	9	17	25	33	41	49	57	
Inches.									*Trees.*
5	0.60	0.18	0.12	0.10	.....	.....	.....	.....	2
6	.64	.23	.17	.12	0.08	.....	.....	.....	8
7	.70	.26	.19	.14	.10	0.06	.....	.....	15
8	.76	.29	.21	.16	.12	.09	.....	.....	16
9	.83	.32	.23	.18	.15	.12	.....	.....	33
10	.91	.35	.26	.21	.17	.14	0.09	.....	37
11	.96	.38	.28	.23	.18	.15	.10	.....	21
12	1.01	.41	.31	.25	.20	.17	.11	.....	12
13	1.05	.44	.34	.27	.22	.18	.12	.....	9
14	1.09	.47	.37	.29	.23	.20	.14	0.11	3
15	1.12	.50	.39	.31	.25	.22	.17	.14	1
16	1.14	.52	.41	.33	.27	.24	.20	.17	2
17	1.16	.54	.43	.35	.29	.26	.23	.20	3
									162

TABLE 21.—*Taper of jack pine trees of different diameters and heights, showing diameter inside bark at different heights above the ground.*

[Based on measurements by H. H. Chapman in Hubbard County, and a few by J. St. J. Benedict in Cass County, Minn., of trees cut in dense, even-aged stands. Measurements taken on jack pine in Roscommon County, Mich., indicated the same taper as given in this table for trees of different diameters and heights.]

20-FOOT TREES.

Diameter breast high.	Height above ground (feet).								Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	
	Diameter inside bark (inches).								
Inches.									*Trees.*
2	2.0	1.9	1.8	1.8	1.4	0.4	.....	.....	9
3	3.1	2.9	2.8	2.7	2.3	.7	.....	.....	4
4	4.1	3.9	3.8	3.6	3.1	1.1	.....	.....	.....
5	5.1	4.9	4.7	4.6	3.9	4.1	.....	.....	1
6	6.1	5.9	5.7	5.5	4.7	1.7	.....	.....	.....
7	7.2	6.9	6.6	6.4	5.5	2.0	.....	.....	.....
8	8.2	7.8	7.6	7.3	6.3	2.3	.....	.....	.....
									14
30-FOOT TREES.									
2	2.0	1.9	1.8	1.8	1.6	1.2	0.5	.....	6
3	3.1	2.9	2.8	2.7	2.4	1.7	.7	.....	22
4	4.1	3.9	3.8	3.6	3.2	2.2	.9	.....	17
5	5.1	4.9	4.7	4.6	4.0	2.8	1.1	.....	7
6	6.1	5.9	5.7	5.5	4.8	3.3	1.3	.....	8
7	7.2	6.9	6.6	6.4	5.6	3.9	1.5	.....	5
8	8.2	7.8	7.6	7.3	6.4	4.4	1.7	.....	.....
9	9.2	8.8	8.5	8.2	7.2	5.0	1.9	.....	.....
10	10.2	9.8	9.5	9.1	8.0	5.5	2.1	.....	.....
									65
40-FOOT TREES.									
2	2.0	1.9	1.8	1.8	1.7	1.7	1.3	0.7	.....
3	3.1	2.9	2.8	2.7	2.5	2.2	1.7	.8	2
4	4.1	3.9	3.8	3.6	3.3	2.8	2.1	1.0	41
5	5.1	4.9	4.7	4.6	4.2	3.4	2.5	1.2	31
6	6.1	5.9	5.7	5.5	5.0	4.1	2.9	1.4	25
7	7.2	6.9	6.6	6.4	5.8	4.7	3.3	1.6	24
8	8.2	7.8	7.6	7.3	6.6	5.3	3.7	1.7	21
9	9.2	8.8	8.5	8.2	7.4	5.9	4.1	1.9	14
10	10.2	9.8	9.5	9.1	8.2	6.5	4.5	2.1	6
11	11.2	10.8	10.4	10.1	9.0	7.1	4.9	2.2	3
12	12.2	11.7	11.4	11.0	9.8	7.7	5.3	2.4	1
13	13.2	12.7	12.3	11.9	10.6	8.3	5.7	2.6	.....
14	14.2	13.6	13.2	12.8	11.3	8.9	6.1	2.7	.....
									168

TABLE 21.—*Taper of jack pine trees of different diameters and heights, showing diameter inside bark at different heights above the ground*—Continued.

50-FOOT TREES.

Diameter breast high.	Height above ground (feet).										Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	
	Diameter inside bark (inches).										
Inches.											*Trees.*
4	4.1	3.9	3.8	3.6	3.5	3.2	2.8	2.1	1.3	.....	8
5	5.1	4.9	4.7	4.6	4.4	3.9	3.3	2.5	1.4	.....	34
6	6.1	5.9	5.7	5.5	5.2	4.6	3.9	2.9	1.6	.....	39
7	7.2	6.9	6.6	6.4	6.0	5.3	4.4	3.3	1.8	.....	36
8	8.2	7.8	7.6	7.3	6.8	6.0	4.9	3.7	2.0	.....	17
9	9.2	8.8	8.5	8.2	7.6	6.7	5.5	4.0	2.2	.....	14
10	10.2	9.8	9.5	9.1	8.4	7.4	6.0	4.4	2.5	.....	14
11	11.2	10.8	10.4	10.1	9.2	8.0	6.6	4.8	2.7	.....	8
12	12.2	11.7	11.4	11.0	10.0	8.7	7.2	5.2	2.9	.....	6
13	13.2	12.7	12.3	11.9	10.8	9.3	7.7	5.6	3.1	.....	2
14	14.2	13.6	13.2	12.8	11.6	10.0	8.2	6.0	3.3	.....	1
15	15.1	14.6	14.1	13.7	12.4	10.7	8.8	6.4	3.5	.....	.....
16	16.1	15.5	15.0	14.6	13.2	11.3	9.4	6.8	3.7	.....	.....
17	17.0	16.4	15.9	15.5	14.0	12.0	9.9	7.2	3.9	.....	.....
18	18.0	17.3	16.8	16.4	14.7	12.7	10.5	7.6	4.1	.....	.....
											179
	60-FOOT TREES.										
6	6.1	5.9	5.7	5.5	5.2	4.8	4.3	3.7	2.9	1.7	21
7	7.2	6.9	6.6	6.4	6.1	5.5	4.9	4.2	3.3	1.9	29
8	8.2	7.8	7.6	7.3	6.9	6.2	5.6	4.8	3.7	2.2	30
9	9.2	8.8	8.5	8.2	7.7	6.9	6.2	5.3	4.0	2.4	24
10	10.2	9.8	9.5	9.1	8.6	7.7	6.9	5.9	4.4	2.6	26
11	11.2	10.8	10.4	10.1	9.5	8.5	7.5	6.4	8.4	2.8	10
12	12.2	11.7	11.4	11.0	10.3	9.2	8.2	6.9	5.2	3.1	6
13	13.2	12.7	12.3	11.9	11.2	10.0	8.8	7.4	5.5	3.3	4
14	14.2	13.6	13.2	12.8	12.0	10.7	9.5	7.9	5.9	3.5	1
15	15.1	14.6	14.1	13.7	12.8	11.5	10.1	8.4	6.3	3.7	.....
16	16.1	15.5	15.0	14.6	13.6	12.2	10.8	9.0	6.7	4.0	.....
17	17.0	16.4	15.9	15.5	14.4	13.0	11.4	9.5	7.1	4.2	1
18	18.0	17.3	16.8	16.4	15.2	13.7	12.0	10.0	7.5	4.4	.....
19	19.0	18.2	17.7	17.3	16.0	14.4	12.7	10.5	7.8	4.6	.....
20	19.9	19.1	18.6	18.2	16.8	15.1	13.4	11.1	8.2	4.9	.....
											152

TABLE 21.—*Taper of jack pine trees of different diameters and heights, showing diameter inside bark at different heights above the ground*—Continued.

70-FOOT TREES.

Diameter breast high.	Height above ground (feet).												Basis.
	1	2	3	4.5	9.15	17.3	25.45	33.6	41.75	49.9	58.05	66.2	
	Diameter inside bark (inches).												
Inches.													*Trees.*
6	6.1	5.9	5.7	5.5	5.3	4.9	4.6	4.2	3.5	2.7	1.7	.....	.....
7	7.2	6.9	6.6	6.4	6.2	5.7	5.3	4.8	4.1	3.2	2.0	.....	1
8	8.2	7.8	7.6	7.3	7.1	6.5	6.0	5.4	4.7	3.6	2.3	.....	3
9	9.2	8.8	8.5	8.2	8.0	7.3	6.7	6.0	5.2	4.0	2.5	.....	6
10	10.2	9.8	9.6	9.1	8.8	8.1	7.4	6.6	5.7	4.4	2.8	.....	14
11	11.2	10.8	10.4	10.1	9.7	8.9	8.1	7.3	6.2	4.8	3.1	.....	10
12	12.2	11.7	11.4	11.0	10.5	9.6	8.8	7.9	6.7	5.2	3.4	.....	8
13	13.2	12.7	12.3	11.9	11.4	10.4	9.5	8.5	7.2	5.6	3.7	.....	2
14	14.2	13.6	13.2	12.8	12.2	11.2	10.2	9.1	7.7	6.0	4.0	.....	4
15	15.1	14.6	14.1	13.7	13.1	12.0	10.9	9.7	8.2	6.4	4.3	.....	1
16	16.1	15.5	15.0	14.6	13.9	12.7	11.6	10.3	8.7	6.8	4.6	.....	4
17	17.0	16.4	15.9	15.5	14.8	13.5	12.3	10.9	9.2	7.2	4.9	.....	2
18	18.0	17.3	16.8	16.4	15.6	14.3	13.0	11.4	9.7	7.6	5.1	.....	.....
19	19.0	18.2	17.7	17.3	16.5	15.1	13.7	12.0	10.2	8.0	5.4	.....	.....
20	19.9	19.1	18.6	18.2	17.3	15.9	14.3	12.6	10.7	8.4	5.7	.....	.....
													55
	80-FOOT TREES.												
8	8.2	7.8	7.6	7.3	7.0	6.7	6.4	6.0	5.4	4.7	3.7	2.5	1
9	9.2	8.8	8.5	8.2	7.9	7.5	7.1	6.7	6.0	5.2	4.1	2.8	4
10	10.2	9.8	9.5	9.1	8.8	8.3	7.8	7.3	6.6	5.8	4.6	3.1	4
11	11.2	10.8	10.4	10.1	9.7	9.1	8.5	7.9	7.2	6.3	5.1	3.4	5
12	12.2	11.7	11.4	11.0	10.6	9.9	9.2	8.6	7.8	6.8	5.6	3.8	6
13	13.2	12.7	12.3	11.9	11.4	10.7	9.9	9.2	8.4	7.4	6.1	4.2	2
14	14.2	13.6	13.2	12.8	12.2	11.4	10.6	9.9	9.0	8.0	6.6	4.6	2
15	15.1	14.6	14.1	13.7	13.1	12.2	11.3	10.5	9.6	8.5	7.1	5.0	1
16	16.1	15.5	15.0	14.6	13.9	13.0	12.0	11.2	10.2	9.1	7.6	5.4	.....
17	17.0	16.4	15.9	15.5	14.8	13.8	12.7	11.8	10.8	9.7	8.1	5.7	.....
18	18.0	17.3	16.8	16.4	15.7	14.6	13.4	12.4	11.4	10.2	8.6	6.1	.....
19	19.0	18.2	17.7	17.3	16.6	15.3	14.1	13.1	12.0	10.7	9.0	6.4	.....
20	19.9	19.1	18.6	18.2	17.4	16.1	14.8	13.7	12.6	11.3	9.5	6.7	.....
													25

TABLE 22.—*Average diameter outside bark at different heights above the ground for jack pine trees of different diameters on quality "poor" and quality "good" sites, in Hubbard County, Minn., for trees grown mostly in dense, even-aged stands 18 to 78 years old on quality "poor," and 20 to 45 years old on quality "good" sites.*

[Measurements by H. H. Chapman, 1905.]

SITE QUALITY "POOR."

Diameter breast high.	Height above ground (feet).								Basis.
	1	9	17	25	33	41	49	57	
	Diameter outside bark (inches).								
Inches.									*Trees.*
1	1.7	0.9	0.4	.....	.....	.....	.....	.....	1
2	2.8	1.8	1.2	.....	.....	.....	.....	.....	11
3	3.9	2.8	2.1	1.1	.....	.....	.....	.....	22
4	5.0	3.7	3.0	2.1	.....	.....	.....	.....	30
5	6.2	4.6	3.9	3.1	2.4	.....	.....	.....	55
6	7.3	5.5	4.8	4.0	3.2	.....	.....	.....	43
7	8.4	6.4	5.7	4.9	4.1	2.9	.....	.....	60
8	9.6	7.4	6.6	5.8	4.9	3.8	.....	.....	37
9	10.7	8.3	7.4	6.6	5.8	4.7	3.1	.....	28
10	11.8	9.3	8.3	7.5	6.6	5.4	3.8	2.2	25
11	12.9	10.3	9.2	8.3	7.3	6.0	4.4	2.7	14
12	13.9	11.2	10.1	9.1	8.0	6.6	5.0	3.2	9
13	14.9	12.2	11.0	10.0	8.7	7.2	5.6	3.7	.....
14	15.9	13.1	11.9	10.7	9.4	7.7	6.1	4.2	3
15	16.9	14.1	12.8	11.5	10.0	8.3	6.6	4.6	1
16	18.0	15.0	13.7	12.3	10.7	8.8	7.0	5.0	.....
17	19.0	16.0	14.6	13.0	11.3	9.4	7.5	5.4	3
									342
SITE QUALITY "GOOD."									
2	2.7	1.7	.....	.....	.....	.....	.....	.....	2
3	3.9	2.6	2.1	.....	.....	.....	.....	.....	8
4	5.1	3.6	2.9	2.3	1.4	.....	.....	.....	26
5	6.3	4.6	3.8	3.0	2.0	.....	.....	.....	30
6	7.5	5.5	4.6	3.7	2.6	.....	.....	.....	26
7	8.6	6.4	5.4	4.4	3.2	1.9	.....	.....	34
8	9.8	7.3	6.2	5.1	3.7	2.1	.....	.....	18
9	10.9	8.2	7.0	5.8	4.3	2.4	.....	.....	22
10	12.0	9.0	7.8	6.5	4.8	2.8	.....	.....	19
11	13.0	9.9	8.6	7.2	5.4	3.3	.....	.....	7
12	14.2	10.8	9.3	7.8	6.0	3.9	.....	.....	4
13	15.2	11.7	10.1	8.5	6.6	4.6	.....	.....	6
14	16.3	12.6	10.9	9.2	7.3	5.3	.....	.....	3
15	17.3	13.5	11.7	9.8	7.9	6.1	.....	.....	.....
16	18.3	14.4	12.5	10.5	8.6	6.8	.....	.....	2
									207

TABLE 23.—*Total volume of stemwood in cubic feet of jack pine trees of different diameters and heights in Minnesota.*

[Based on taper curves.]

Diameter breast high.	Total height of trees (feet).							Bark.	Basis.
	20	30	40	50	60	70	80		
	Total volume, including bark (cubic feet).								
Inches.								*Per cent.*	*Trees.*
2	0.3	0.4	0.5	.....	.....	.....	.....	22.8	15
3	.6	.8	1.0	1.3	.....	.....	.....	21.3	28
4	1.1	1.4	1.8	2.3	.....	.....	.....	20.0	66
5	1.7	2.1	2.7	3.5	.....	.....	.....	19.0	73
6	2.5	3.1	3.9	5.0	6.1	7.1	.....	18.1	93
7	3.4	4.2	5.2	6.8	8.3	9.7	.....	17.4	95
8	4.4	5.4	6.7	8.7	10.7	12.5	14.8	16.9	72
9	.....	6.9	8.5	10.8	13.3	15.8	18.7	16.4	62
10	.....	8.3	10.3	13.4	16.0	19.1	23.0	16.0	64
11	.....	.....	12.4	15.8	19.4	23.0	27.0	15.6	36
12	.....	.....	14.5	18.5	23.0	27.0	32.0	15.2	27
13	.....	.....	16.6	22.0	26.0	31.0	38.0	14.7	10
14	.....	.....	19.2	25.0	30.0	36.0	43.0	14.2	8
15	.....	.....	.....	28.0	34.0	40.0	49.0	13.6	2
16	.....	.....	.....	31.0	38.0	46.0	55.0	13.0	4
17	.....	.....	.....	35.0	43.0	51.0	61.0	12.3	3
18	.....	.....	.....	38.0	47.0	56.0	66.0	11.5	.....
19	.....	.....	.....	.....	52.0	62.0	74.0	10.7	.....
20	.....	.....	.....	.....	56.0	67.0	80.0	9.8	.....
									658

TABLE 24.—*Merchantable volume of stemwood in cubic feet of jack pine trees of different diameters and heights in Minnesota.*

[Based on taper curves. Stump height, 1 foot; top diameter outside bark, 3 inches.]

Diameter breast high.	Total height of trees (feet).							Bark.	Basis.
	20	30	40	50	60	70	80		
	Merchantable volume, including bark (cubic feet).								
Inches.								*Per cent.*	*Trees.*
4	0.9	1.1	1.5	2.1	.....	.....	.....	20.0	66
5	1.4	1.8	2.5	3.3	.....	.....	.....	19.0	73
6	2.2	2.7	3.5	4.6	5.8	6.9	.....	18.1	93
7	3.0	3.8	4.8	6.3	7.7	9.4	.....	17.4	95
8	4.0	4.9	6.1	8.0	10.1	12.0	14.2	16.9	72
9	.....	6.2	7.8	10.2	12.5	15.2	18.0	16.4	62
10	.....	7.7	9.6	12.3	15.4	18.3	22.0	16.0	64
11	.....	.....	11.4	14.8	18.2	22.0	26.0	15.6	36
12	.....	.....	13.5	17.3	22.0	26.0	31.0	15.2	27
13	.....	.....	15.5	20.0	25.0	30.0	36.0	14.7	10
14	.....	.....	18.0	23.0	29.0	34.0	41.0	14.2	8
15	.....	.....	.....	26.0	32.0	39.0	47.0	13.6	2
16	.....	.....	.....	29.0	37.0	44.0	52.0	13.0	4
17	.....	.....	.....	33.0	41.0	49.0	59.0	12.3	3
18	.....	.....	.....	36.0	46.0	54.0	65.0	11.5	.....
19	.....	.....	.....	.....	50.0	59.0	72.0	10.7	.....
20	.....	.....	.....	.....	55.0	66.0	79.0	9.8	.....
									615

TABLE 25.—*Volume in board feet of jack pine trees of different diameters and heights in Minnesota.*

[Scaled by Scribner Decimal C log rule. Stump height, 1 foot: top diameter inside bark, 5.5 inches. Based on taper curves, scaled mostly as 16.3-foot logs, with a few shorter logs where necessary.]

Diameter breast high.	Total height of trees (feet).							Basis.
	20	30	40	50	60	70	80	
	Volume (board feet).							
Inches.								*Trees.*
8	9	10	11	15	23	36	50	72
9	.....	15	17	24	34	50	68	62
10	.....	20	23	34	46	65	87	64
11	.....	.....	29	43	59	81	108	36
12	.....	.....	36	53	73	98	130	27
13	.....	.....	43	64	88	116	152	10
14	.....	.....	51	76	104	136	176	8
15	.....	.....	.....	90	121	158	203	2
16	.....	.....	.....	104	139	182	232	4
17	.....	.....	.....	118	158	207	263	3
18	.....	.....	.....	134	178	234	294	.....
19	.....	.....	.....	.....	198	262	327	.....
20	.....	.....	.....	.....	220	291	363	.....
								288

TABLE 26.—*Volume in board feet of jack pine trees of different diameters, and number of logs per tree, in Minnesota.*

[Scaled by Scribner Decimal C log rule. Stump height, 1 foot; top diameter inside bark, 5.5 inches. Based on taper curves, scaled mostly as 16.3-foot logs, with a few shorter logs where necessary.]

Diameter breast high.	Number of 16-foot logs.							Basis.
	1	1½	2	2½	3	3½	4	
	Volume (board feet).							
Inches.								*Trees.*
8	14	24	39	54	.....	.....	.....	72
9	17	27	42	59	.....	.....	.....	62
10	20	30	46	65	82	.....	.....	64
11	.....	33	51	72	93	.....	.....	36
12	.....	37	57	81	105	132	.....	27
13	.....	41	64	90	118	147	.....	10
14	.....	45	73	101	131	163	187	8
15	.....	.....	83	113	146	181	213	2
16	.....	.....	94	127	163	201	239	4
17	.....	.....	106	141	180	223	266	3
18	.....	.....	121	156	198	245	294	.....
19	.....	.....	.....	171	217	269	322	.....
20	.....	.....	.....	188	237	293	351	.....
								288

TABLE 27.—*Volume in board feet of white pine trees of different diameters and heights.*

[Based on mill cut of lumber from 1,578 trees in southern New Hampshire, 60 per cent being round-edged lumber. Measurements by L. Margolin, 1905.]

Diameter breast high.	Total height of trees (feet).					
	30	40	50	60	70	80
Inches.	*Board feet.*	*Board feet.*	*Board feet.*	*Board feet.*	*Board feet.*	*Board feet.*
5	8	12	15	.....	.....	.....
6	13	20	23	27	29	.....
7	18	28	34	39	44	.....
8	24	36	45	53	62	.....
9	32	44	56	69	81	93
10	41	53	70	85	103	119
11	.....	63	84	103	126	147
12	.....	73	100	125	151	177
13	.....	84	117	148	180	210
14	.....	95	137	173	210	243
15	.....	105	158	200	241	282
16	.....	.....	181	230	277	323
17	.....	.....	209	261	313	368
18	.....	.....	238	297	352	411
19	.....	.....	270	336	393	460
20	.....	.....	302	379	436	506

This table was used in calculating mill-tally yields in Table 10. It is given for comparison with Table 25 showing board-feet contents of jack pine trees of different diameters and heights scaled by Scribner Decimal C log rule.

TABLE 28.—*Number of ties per tree in jack pine trees of different diameters in western Ontario.*

From an article by L. M. Ellis in the Forestry Quarterly, March, 1911. Basis 100 trees. Equivalent in board feet added by the author.

Diameter breast high.	Total height (average).	Age (average).	No. 1, 7″ x 7″ x 8′	No. 2, 6″ x 6″ x 8′	Cull, 5″ x 5″ x 8′	Total.	Equivalent in board feet.
Inches.	*Feet.*	*Years.*					
10	56	48	.....	0.8	1.1	1.9	37
11	61	55	0.3	2.0	1.0	3.3	74
12	66	62	1.2	1.8	.8	3.8	94
13	70	70	2.2	1.5	.8	4.5	119
14	74	80	3.2	1.5	.4	5.1	145
15	77	91	3.8	1.3	.3	5.4	158
16	81	107	4.0	1.2	.2	5.4	160

TABLE 29.—*Stand of trees on jack pine land, Roscommon and Crawford Counties, Mich.*

[Average of 100 acres. Measurements by T. H. Sherrard, 1901.]

Diameter breast high.	Jack pine.	Scarlet oak.	Norway pine.	Aspen.	Red oak.	White pine.	White oak.	Tamarack.	Spruce	White ash.	Total.
Inches.											
1	11.86	2.09	0.29	0.42	0.14	0.20	0.08	0.04	.....	0.01	.....
2	15.69	2.19	.22	.19	.23	.11	.....	.06	0.04	.....	.....
3	14.42	1.20	.10	.03	.12	.01	.04	.01	.01	.01	.....
4	14.47	.97	.08	.02	.03	.03	.01	.01	.....	.01	.....
5	12.02	.53	.04	.01	.02	.01	.03	.05	.02	.....	.....
6	8.26	.40	.03	.....	.01	.....	.05	.....	.....	.....	.....
7	4.68	.26	.01	.....	.02	.....	.04	.....	.....	.....	.....
8	2.62	.15	.04	.....	.02	.....	.01	.01	.....	.....	.....
9	2.69	.07	.01	.....	.....	.....	.....	.....	.....	.....	.....
10	1.31	.03	.04	.....	.01	.01	.....	.....	.....	.....	.....
11	.27	.04	.04	.....	.....	.....	.....	.....	.....	.....	.....
12	.05	.....	.01	.....	.....	.....	.01	.....	.....	.....	.....
13	.01	.....	.02	.....	.....	.....	.....	.....	.....	.....	.....
14	.....	.....	.06	.....	.....	.....	.....	.....	.....	.....	.....
15	.....	.....	.05	.....	.....	.....	.....	.....	.....	.....	.....
16	.....	.....	.05	.....	.....	.....	.....	.....	.....	.....	.....
17	.....	.....	.10	.....	.....	.....	.....	.....	.....	.....	.....
18	.....	.....	.05	.....	.....	.01	.....	.....	.....	.....	.....
19	.....	.....	.06	.....	.....	.....	.....	.....	.....	.....	.....
21	.....	.....	.01	.....	.....	.01	.....	.....	.....	.....	.....
23	.....	.....	.....	.....	.....	.01	.....	.....	.....	.....	.....
24	.....	.....	.01	.....	.....	.....	.....	.....	.....	.....	.....
25	.....	.....	.01	.....	.....	.....	.....	.....	.....	.....	.....
Total	88.35	7.93	1.36	.67	.60	1.40	.27	.18	.07	.03	99.86
Per cent	88.48	7.94	1.36	.67	.60	.40	.27	.18	.07	.03	100.00
Average diameter	4.40	3.50	10.30	1.80	3.30	6.10	5.10	3.60	3.20	3.00	.....

TABLE 30.—*Stand of trees on jack pine land, site quality*[1] *in western Ontario—Average of 11 acres.*

[From an article by L. M. Ellis in the Forestry Quarterly, March, 1911.]

Diameter breast high.	Jack pine.	White birch.	Aspen.	Black spruce.	Balsam.
	Average number of trees per acre.				
Inches.					
4	1.0	26.2	0.8	13.0	.....
5	1.2	24.7	1.7	21.5	0.5
6	1.2	22.5	4.2	19.2	.25
7	6.0	25.0	2.7	15.2	.75
8	12.5	16.7	4.2	9.5	.75
9	17.5	7.0	4.5	6.5	.50
10	12.5	2.5	3.7	2.5	.50
11	12.2	1.7	3.0	2.2	.25
12	11.2	1.2	2.5	1.7	.25
13	11.0	.5	1.7	.02	.25
14	6.0	.....	.7	.....	.25
15	3.1	.....	.02	.....	.....
16	1.0	.....	.....	.....	.....
Total	93.0	128.0	27.0	91.0	4.0
Per cent	27.0	37.0	8.0	27.0	1.0
Trees 10 inches and over in diameter, breast high.					
Total	57.0	59.0	11.6	6.4	1.50
Per cent	42.0	44.0	8.4	4.6	1.0

Yield of jack pine on these acres about 25 per cent higher than the average for this type in western Ontario.

[1] Deep, well-drained soil on which jack pine produces its largest returns in sizes suitable for cross ties.

TABLE 31.—*Stand of trees on jack pine land, site quality*[1] *in western Ontario—Average of 10 acres.*

[From an article by L. M. Ellis in the Forestry Quarterly, March, 1911.]

Diameter breast high.	Jack pine.	Black spruce.	Balsam fir.	Larch.	Birch.	Aspen.
	Average number of trees per acre.					
Inches.						
4 and under	8.2	124.4	44.1	0.8	20.8	0.4
5	8.8	41.7	2.2	1.3	4.3	.6
6	16.5	40.4	.4	1.6	8.8	1.8
7	27.4	16.4	.3	2.0	4.8	1.5
8	32.8	14.1	.2	1.4	1.5	1.3
9	16.8	12.3	.2	.6	.4	.5
10	9.6	9.0	.....	.3	.....	.2
11	3.2	3.0	.....	.2	.....	.1
12	1.6	.....	.....	.1	.....	.....
13	.5	.....	.....	.....	.....	.....
Total	125.4	235.3	47.4	8.3	40.6	6.4
Per cent	27.0	50.4	11.2	1.5	8.6	1.3
Trees 10 inches and over in diameter breast high.						
Total	14.9	12.0	.....	0.6	.....	0.3
Per cent	54.0	43.0	.....	2.0	.....	1.0

[1] Includes higher hills and ridges, with scanty soil and lowlands bordering muskegs. In northern Manitoba and northern Ontario the largest part of the interior regions is occupied by this type, on which jack pine rarely reaches merchantable sizes, and never in such bodies as to make commercial exploitation profitable.

TABLE 32.—*Height and yield per acre of managed or normal stands of Scotch pine (Pinus sylvestris) on different qualities of site at different ages.*

[From "Yield Tables for the Scotch Pine," by Wilhelm Weise, converted into English measure and arranged by William Schlich, 1880. Based on 351 Scotch pine woods in Alsace, Baden, Bavaria, Prussia, and Saxony. Cubic feet reduced to cords by dividing by 90.]

Age.	Average height of stand.					Final yield per acre of wood 3 inches and over in diameter.				
	Quality of site.					Quality of site.				
	I.	II.	III.	IV.	V.	I.	II.	III.	IV.	V.
Years.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Cords.*	*Cords.*	*Cords.*	*Cords.*	*Cords.*
25	31	25	21	18	15	16.22	5.56	3.78	1.89	1.56
30	38	31	26	22	19	24.56	13.00	9.22	4.89	4.00
35	45	36	30	26	22	34.00	23.78	16.00	9.89	6.78
40	51	41	35	31	25	43.00	31.44	21.89	14.33	10.00
45	58	46	39	34	28	50.00	38.56	26.22	18.78	13.00
50	64	51	43	37	31	56.22	43.78	30.00	22.67	15.89
55	68	55	47	40	33	61.56	48.22	33.44	26.00	18.44
60	72	60	51	42	35	66.89	52.11	36.67	29.00	20.78
65	76	64	54	45	37	71.44	55.44	39.67	31.89	23.00
70	80	67	57	47	39	75.44	58.33	42.44	34.11	24.89

TABLE 33.—*Intermediate returns from thinnings in normal stands of Scotch pine on different qualities of site at different ages.*

[From same publication as Table 32.]

Period of years.	Yield per period of years.					Age of stand in years.	Cumulative intermediate yield.				
	Quality of site.						Quality of site.				
	I.	II.	III.	IV.	V.		I.	II.	III.	IV.	V.
	Cords.	*Cords.*	*Cords.*	*Cords.*	*Cords.*		*Cords.*	*Cords.*	*Cords.*	*Cords.*	*Cords.*
20 to 25	1.41	0.08	0.03	.....	.....	25	2.17	0.08	0.03	.....	.....
25 to 30	2.09	.56	.50	0.19	0.10	30	4.26	.63	.53	0.19	0.10
30 to 35	2.81	1.50	1.34	.52	.24	35	7.07	2.13	1.88	.71	.34
35 to 40	3.28	2.42	1.87	.94	.36	40	10.34	4.56	3.74	1.66	.70
40 to 45	3.49	2.81	2.19	1.16	.52	45	13.83	7.37	5.93	2.81	1.22
45 to 50	3.51	3.01	2.29	1.27	.61	50	17.34	10.38	8.22	4.08	1.83
50 to 55	3.63	3.17	2.33	1.42	.68	55	20.98	13.54	10.56	5.50	2.51
55 to 60	3.47	3.11	2.26	1.42	.63	60	24.44	16.66	12.81	6.92	3.14
60 to 65	3.41	3.03	2.04	1.48	.63	65	27.86	19.69	14.86	8.40	3.78
65 to 70	3.30	2.92	1.99	1.40	.63	70	31.16	22.61	16.84	9.80	4.41

TABLE 34.—*Summary of sample plots, site quality "good."*

[Total area of plots, 42.322 acres; average area, 0.694 acre. Measurements by H. H. Chapman, Hubbard County, Minn., 1905. Plot numbers in parentheses indicate selected plots used in construction of yield table.]

Plot number.	Age.	Total.	Living trees per acre.					Average.		Living trees.		Dead trees, per cent of living volume.	Density of stand.
			Jack pine.		Other species.[1]			Diameter, breast high, 5 inches and over.	Dominant height.	Total basal area.	Total yield per acre.		
			5 to 9 inches.	10 inches and over.	1 to 4 inches.	5 to 9 inches.	10 inches and over.						
	Years.							*Inches.*	*Feet.*	*Square feet.*	*Cubic feet.*[2]		
94	18	1,477	38	.....	21	.....	.....	5.2	27	51	726	0.6	1.0
129	20	2,817	11	.....	.....	.....	.....	5.0	31	91	1,347	1.7	1.0
74	22	532	188	.....	1	.....	.....	5.4	33	51	824	.7	.9
(75)	23	847	147	.....	20	.....	.....	5.3	36	56	941	.5	1.0
(78)	23	1,021	128	.....	8	.....	.....	5.6	32	60	911	.....	1.0
(31)	29	536	290	.....	6	.....	.....	6.5	37	80	1,457	1.4	.9
67	29	528	270	.....	41	1	.....	5.9	41	67	1,280	.8	.9
120	29	679	400	3	28	1	.....	6.5	47	109	2,403	1.4	1.0
(101)	31	553	268	3	16	4	.....	6.4	44	75	1,616	2.4	.95
104	31	573	285	.....	26	3	.....	6.0	38	74	1,378	1.2	.85
110	31	553	293	1	6	.....	.....	6.2	41	75	1,421	1.1	.9
(139)	31	675	331	4	10	13	.....	6.3	43	94	2,009	2.7	1.0
(121)	32	526	373	2	23	4	.....	6.7	50	102	2,523	1.0	.95
(124)	32	581	342	.....	7	.....	.....	6.6	45	94	1,966	2.1	.95
100	33	1,020	276	1	7	.....	.....	6.0	41	87	1,591	.8	1.0
123	33	675	342	2	11	6	.....	6.2	44	92	1,761	1.5	.9
(41)	34	505	406	1	14	3	.....	6.5	45	103	2,100	3.0	.95
(113)	34	708	343	7	19	1	.....	6.4	57	98	2,075	2.6	1.0
(119)	34	437	311	9	22	6	.....	6.9	46	93	1,110	.9	.95
140	34	601	299	7	47	13	1	6.5	43	90	1,805	1.7	.95
26	35	871	368	.....	3	.....	.....	5.7	47	94	1,987	5.3	1.0
30	35	741	375	.....	.....	.....	.....	6.1	43	99	1,959	3.1	.95
46	35	657	529	9	20	6	.....	6.7	52	144	3,529	5.9	.95
47	35	375	241	49	125	81	6	7.5	54	130	3,335	.1	.85
(54)	35	423	332	30	12	7	.....	7.2	52	109	2,680	2.5	.95
(127)	35	524	338	8	4	.....	.....	7.0	50	101	2,411	2.5	.95
136	35	399	255	17	16	14	1	6.9	49	84	1,951	1.3	.9
(44)	36	750	453	1	13	.....	.....	6.0	46	109	2,461	7.2	1.0
45	36	611	487	.....	35	13	.....	6.5	49	126	2,977	3.9	.9
48	36	430	355	11	108	15	.....	6.9	55	110	2,899	2.9	.95
51	36	795	556	.....	10	3	.....	6.1	52	132	3,237	6.2	.9
(52)	36	572	434	4	13	4	1	6.6	52	116	2,855	6.7	.95
(53)	36	559	436	2	1	1	.....	6.4	50	107	2,638	4.6	.95
(55)	36	721	428	7	10	2	.....	6.1	51	111	2,644	5.5	.95
(56)	37	606	422	2	10	.....	.....	6.4	50	107	2,690	5.6	.95
138	37	560	300	10	24	5	.....	6.7	47	92	2,048	1.5	.95
10	38	261	193	41	2	1	.....	7.9	62	83	2,435	14.8	.9
(130)	38	499	377	17	.....	.....	.....	6.7	53	104	2,667	6.1	.9
134	38	427	286	2	153	19	.....	6.5	46	84	1,841	1.8	.9
43	39	903	616	.....	15	.....	.....	6.1	50	146	3,653	7.2	1.0
(50)	39	524	473	2	.....	4	.....	6.6	49	118	2,835	12.1	.95
(135)	39	526	377	23	21	4	1	6.9	51	113	2,805	5.3	.95
59	40	343	221	47	4	5	.....	7.9	55	97	2,373	9.1	.85
(131)	40	337	242	46	6	1	1	8.0	63	104	3,212	4.5	.9
128	41	678	552	3	.....	.....	.....	6.3	55	131	3,620	12.3	1.0
2	42	399	326	17	9	14	.....	7.0	56	100	2,729	7.3	.9
(133)	42	601	369	13	8	1	.....	6.6	57	103	3,010	4.3	.9
40	44	424	317	47	.....	.....	.....	7.4	56	114	3,560	3.1	.85
132	45	414	255	44	10	9	2	7.4	58	100	2,761	2.2	.95
3	46	317	265	25	1	3	.....	7.4	61	91	2,725	5.1	.85
70	53	360	328	13	.....	.....	.....	7.1	68	97	3,327	29.7	.9
(106)	53	435	350	30	1	.....	.....	7.3	69	114	3,902	11.1	.9
(112)	53	491	463	15	.....	.....	.....	6.8	63	125	3,924	12.8	.95
111	54	459	414	16	.....	.....	.....	7.1	60	119	3,472	10.8	.9
115	54	592	492	2	.....	.....	.....	6.4	55	117	3,214	11.3	1.0
(126)	54	615	520	.....	.....	.....	.....	6.3	57	122	3,580	15.0	1.0
117	56	480	441	8	.....	.....	.....	6.8	60	116	3,555	13.6	1.0
(122)	56	525	486	4	.....	.....	.....	6.6	61	120	3,680	15.4	.95
(19)	57	237	196	37	3	9	2	8.2	63	91	3,683	23.3	.8
107	59	453	412	10	.....	.....	.....	6.9	61	112	3,408	10.6	.9
(21)	62	345	280	50	1	22	2	7.8	65	119	3,719	20.0	.9

[1] Includes Norway and some white pine.
[2] All trees 2 inches and over in diameter breast high. Total volume, including bark.

TABLE 35.—*Summary of sample plots, site quality "poor."*

[Total area of plots, 47.924 acres; average area 0.715 acre. Measurements by H. H. Chapman, Hubbard County, Minn., 1905. Plot numbers in parentheses indicate selected plots used in construction of yield tables.]

Plot number.	Age.	Total.	Living trees per acre.					Average.		Living trees.		Dead trees, per cent of living volume.	Density of stand.
			Jack pine.		Other species.[1]			Diameter, breast high, 5 inches and over.	Dominant height.	Total basal area.	Total yield per acre.		
			5 to 9 inches.	10 inches and over.	1 to 4 inches.	5 to 9 inches.	10 inches and over.						
	Years.							*Inches.*	*Feet.*	*Square feet.*	*Cubic feet.*[2]		
98	24	665	157	.....	2	.....	.....	5.2	31	50	762	.....	0.85
68	27	810	167	.....	10	2	.....	5.3	36	57	975	1.0	.9
(77)	30	717	172	.....	8	.....	.....	5.9	37	57	993	.6	.95
99	30	697	252	.....	22	1	.....	5.6	38	64	1,139	1.5	.9
103	30	520	186	7	9	2	.....	6.5	40	62	1,118	.5	.95
60	31	829	199	.....	4	.....	.....	6.1	39	69	1,287	3.1	.95
76	32	672	272	.....	88	.....	.....	5.7	37	69	1,224	.6	.95
(108)	32	855	114	.....	.....	.....	.....	5.2	38	49	881	7.2	.95
11	34	832	153	.....	12	.....	.....	5.6	39	56	1,048	1.9	.95
(38)	34	603	307	.....	.....	.....	.....	5.8	41	74	1,288	1.8	.9
(79)	34	1,087	158	.....	3	.....	.....	5.4	36	65	1,095	3.2	1.0
102	34	458	159	1	8	.....	.....	6.1	38	47	851	1.2	.9
81	35	915	262	1	6	.....	.....	5.8	42	75	1,451	1.4	.95
34	36	976	216	2	13	.....	.....	5.7	41	81	1,530	3.7	1.0
42	36	507	282	3	21	18	1	6.4	43	84	1,637	3.6	.85
(27)	37	553	264	9	.....	.....	.....	6.2	47	71	1,461	4.0	.95
80	37	1,162	224	.....	.....	.....	.....	5.4	40	81	1,546	10.5	1.0
82	37	1,220	57	.....	.....	.....	.....	5.2	33	53	805	3.7	.9
105	37	1,125	261	.....	1	.....	.....	5.5	44	89	1,831	3.8	1.0
20	38	262	244	14	.....	3	.....	7.5	60	80	2,056	33.6	.75
32	38	613	241	17	12	.....	1	6.6	46	80	1,712	2.4	.95
39	38	538	244	15	13	2	.....	6.6	53	78	2,055	2.7	.8
49	38	215	174	17	66	54	.....	7.4	50	80	1,846	.1	.75
137	38	403	225	23	27	3	.....	7.1	48	78	1,769	1.8	.9
4	39	625	238	10	25	.....	.....	6.4	48	78	1,705	2.1	.9
(37)	39	776	259	.....	.....	.....	.....	5.5	37	70	1,251	10.6	.95
24	40	437	340	7	6	4	.....	6.7	52	91	2,198	5.3	.9
13	41	800	169	.....	10	.....	.....	5.5	36	63	1,092	4.4	.95
(109)	42	505	275	7	6	3	.....	6.4	48	76	1,679	1.4	.9
6	51	268	242	24	20	39	.....	7.5	60	96	2,823	21.9	.8
(89)	51	573	445	.....	.....	.....	.....	6.1	51	98	2,410	6.3	.9
(14)	52	430	360	.....	3	3	.....	6.4	53	88	2,301	12.8	.85
(12)	53	258	211	23	3	.....	.....	7.7	58	77	2,207	12.4	.85
83	53	577	416	.....	.....	.....	.....	5.9	50	91	2,066	6.9	.9
85	54	531	342	.....	.....	.....	.....	5.9	53	78	1,894	5.6	.8
87	54	424	329	3	.....	.....	.....	6.4	53	81	2,028	9.7	.9
116	54	532	452	4	.....	.....	.....	6.6	54	113	2,859	8.9	1.0
125	54	563	461	2	.....	.....	.....	6.2	53	106	2,667	9.9	.95
63	55	505	383	.....	.....	.....	.....	5.9	54	83	2,092	20.7	.85
65	55	397	354	5	2	.....	.....	6.6	60	89	2,642	16.8	.8
71	55	348	308	22	.....	.....	.....	7.3	56	98	2,733	14.5	.9
72	55	397	327	.....	.....	.....	.....	6.2	57	74	2,039	13.5	.8
(88)	55	563	372	3	.....	.....	.....	6.2	54	92	2,434	6.0	.95
(91)	55	694	449	.....	.....	.....	.....	5.8	48	99	2,414	6.0	.85
(114)	55	473	389	.....	.....	.....	.....	6.3	55	92	2,514	15.1	.9
(118)	55	490	450	8	.....	.....	.....	6.7	61	115	3,345	12.4	.95
15	56	402	271	5	14	3	.....	6.7	57	77	2,121	8.8	.8
66	56	548	311	.....	.....	.....	.....	5.8	50	76	1,669	15.7	.8
62	57	365	322	.....	.....	.....	.....	6.0	50	67	1,680	13.4	.75
84	57	368	259	.....	.....	.....	.....	5.8	59	55	1,539	8.1	.9
35	58	276	214	50	3	2	3	8.1	61	98	3,059	8.3	.9
61	58	578	312	.....	.....	.....	.....	5.9	55	79	1,954	11.4	.8
(28)	59	223	159	64	.....	2	.....	8.7	62	93	2,764	46.1	.85
(93)	59	537	427	.....	.....	.....	.....	6.3	52	101	2,562	13.8	.85
9	60	301	250	11	.....	.....	.....	6.8	57	70	1,867	29.4	.85
86	62	504	386	.....	.....	.....	.....	6.3	57	93	2,488	8.4	.95
8	63	348	276	26	2	2	.....	7.2	61	90	2,611	16.8	.9
(29)	63	300	246	37	2	3	.....	7.6	62	92	2,743	40.2	.8
25	64	244	163	78	.....	.....	1	8.8	65	102	3,148	8.4	.9
33	66	351	316	24	.....	.....	1	7.5	63	105	3,110	16.4	.9
16	68	293	221	30	3	17	.....	7.7	61	91	2,595	7.2	.8
17	68	316	263	36	3	3	1	7.5	58	94	2,622	6.9	.9
1	70	211	144	67	.....	4	.....	8.8	62	90	2,897	3.1	.85
(22)	70	436	368	14	.....	3	.....	6.9	58	105	2,957	8.9	.9
7	71	249	230	14	67	133	2	7.2	58	112	3,223	14.9	.85
5	75	258	244	10	22	78	1	7.1	60	93	2,697	17.2	.85
23	78	250	240	8	30	50	.....	7.5	62	94	2,826	28.9	.8

[1] Includes Norway and some white pine.
[2] All trees 2 inches and over in diameter breast high. Total volume including bark.

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